Call for Evidence – BEIS Committee

The Semiconductor Industry in the UK

Submission by the

UK Electronics Skills Foundation

June 2022

6. Does the UK have the required skills, talent and diversity to be able to boost its current semiconductor industry and to respond to future disruption?

INTRODUCTION

This document provides an overview of the UK's semiconductor integrated circuit (IC) design skills landscape, followed by specific recommendations for addressing the severe skills shortage that is a defining feature of that landscape. The UK's participation in, and leadership of, global technology advancement is being hampered by this chronic skills shortage.

It is important make clear that this document covers only semiconductor design, as distinct from IC manufacturing and the wider semiconductor eco-system[1]. IC manufacturing is intrinsically linked to IC design and is also experiencing a skills shortage but is sufficiently distinct to warrant its own analysis and would likely benefit from different recommendations.

HISTORY

It can be argued that there has been a global shortage of semiconductor IC design skills since the moment that the first monolithic IC was demonstrated in 1960. The reason is twofold:

1. ICs represented a revolutionary, practical and immensely valuable way of getting electronic functionality into smaller and smaller form factors. As a result, the demand for semiconductor devices has consistently grown since 1960, reaching historically unprecedented levels in late 2020 and sustaining those levels to the present day.

2. IC design is difficult and complex.

THE VALUE OF IC DESIGN

At a recent round table of IC design CTOs and VPs Engineering, the following question was asked to the collective:

'What financial value would you attribute to an IC Design Engineer in any given year?'

One CTO responded:

[1] This article provides a good overview and explanation about the semiconductor eco-system: https://www.linkedin.com/pulse/semiconductor-ecosystem-explained-steve-blank/

'*Well, we're a 25 million pound chip company and we have 25 IC design engineers. So 1 million pounds each.'*

This vignette highlights an essential consideration in relation to the value of semiconductor IC design to the UK economy: **IC design is a fundamental enabling technology.** Every IC design engineer can be viewed as having a mini economic ecosystem on his/her shoulders. In an IC design organisation, dozens of professionals depend on the success of the IC design team.

Note that for the purposes of this document, IC design will be used as a blanket term for Analogue IC design, Digital IC design and IC Verification engineering.

A PERFECT STORM

DEMAND UP, SUPPLY DOWN

As previously mentioned, the semiconductor IC design industry has seen high global skills demand since its inception. Until recently, the pattern was consistent: underlying demand accelerated by one primary industry driver or 'revolution', for example PCs (early 1980s onwards), mobile phones (mid 1990s onwards), smartphones and wireless devices (2010 onwards). However the data revolution of 2020 onwards touches not one or two industries but every industry. Some obvious examples are space exploration and communication, electrification and automation of all forms of transport, IoT and remote monitoring, smart cities, medical technology, fintech / banking technology, argitech ….. the list is almost endless. The result is that every industry – essentially the global economy - is simultaneously driving up demand for ICs, and in turn, IC design skills.

This explosive increase in demand has been accompanied by a reduction in UK skills supply. Prior to Brexit there was a small but steady, net positive, stream of IC design engineers coming to the UK from mainland Europe. Brexit dammed that stream. At the same time, IC design salaries have increased in India and other smaller hubs (Egypt, Brazil, Italy, Greece) to the point where the UK is no longer an attractive standard of living option for many international candidates. In addition, geo-political factors and Chinese investment in home-grown IC design companies has reduced Chinese applications.

These factors, combined with chronic under-enrolment in UK electronics degrees (covered in detail later in this document), make up most of the ingredients in the recipe for the 'perfect skills storm' that now faces the UK IC design industry. The final ingredient is perhaps less obvious….

UK SUCCESS STORY

The UK Government has done an exceptional job of making the UK an attractive place to establish and grow a start-up or establish a design presence in the UK (the exception is visa policy, covered in more detail later). The R&D tax credit scheme is a particular highlight. Combined with the UK's natural flair for innovation, which is particularly prevalent in the semiconductor industry, the result is a UK success story. ARM's continuing strength, the 2.4 billion USD CSR acquisition by Qualcomm, Imagination, Dialog – these are all trailblazing companies, now being followed by a plethora of start-ups (in areas such as quantum computing, AI and optical) as well as companies such as Nordic, Codasip and SiFive, who are establishing major design centres in the UK.

The success of the UK IC design industry is thus the final driver of skills demand which may, paradoxically, result in its own stagnation if the current skills shortage is not addressed.

SCALE OF PROBLEM

There are approximately 1200 IC design professionals in the UK. Over 80% of UK companies with any IC design capability are seeking new engineers, to a total count of over 1000 engineers. An executive at Nordic Semiconductor recently stated: '*if we could find 100 digital IC designers, we'd hire them all'.* Metaphorically, next to every IC designer there is an empty seat.

The cost of these empty seats to the UK economy, and UK competitiveness, is impossible to calculate. Suffice to say that semiconductors are the fundamental building block of the present and future world economy depends on semiconductor technology. It behoves the UK Government and the technology community to work together to fill those seats.

RECOMMENDATIONS

SHORT TERM

1. Visa Process

Any international IC designer with the experience and talent to contribute to the UK economy should be encouraged to consider the UK as a career destination. All obstacles to attracting them should be removed. Currently, the UK's visa process is a significant obstacle. To obtain a visa licence, companies must pay a fee and the associated legal costs. Companies then pay an additional fee for every visa candidate. Most pernicious is the 'NHS surcharge', which financially is costly to companies and psychologically sends a message to visa candidates that are less deserving of care than UK citizens even though they are taxpayers contributing to the UK economy.

WE RECOMMEND THAT THE GOVERNMENT IMMEDIATELY ABOLISH THE NHS SURCHARGE AND MAKE THE VISA PROCESS COST NEUTRAL FOR COMPANIES HIRING IC DESIGNERS

2. International Outreach

The message of Brexit has been interpreted by many professionals around the world that the UK is anti-immigration. In addition, Covid has generated a sense of inertia / resistance to change among people all over the world, which leads to a reluctance to consider international relocation.

A targeted outreach programme could overcome these obstacles. We envisage a UK delegation travelling to specifically chosen IC design hubs and 'pitching' to engineers and assessing their interest in UK opportunities. Shortlisted engineers could be interviewed in person prior to being introduced to appropriate UK companies.

WE RECOMMEND UNDERTAKING MARKET RESEARCH WITH LEADING IC DESIGN ORGANISATIONS TO GAUGE INTEREST IN THE IDEA OF AN OUTREACH PROGRAMME. IT IS LIKELY THAT THE PILOT FOR SUCH A PROGRAMME WOULD BE INDUSTRY FUNDED. GOVERNMENT WOULD BE ENCOURAGED TO PROVIDE SUPPORTING MARKETING MATERIAL. A SUCCESSFUL PILOT MIGHT LEAD TO A JOINT FUNDED INDUSTRY / GOVERNMENT PROGRAMME.

MEDIUM TERM

3. Targeting current undergraduates

Electronics degrees are wide-ranging, covering a large number of different topics and disciplines. Semiconductor IC design is one of the most complex and challenging topics within electronics degrees. Our belief is that IC design is underrepresented in many undergraduate programmes. It is also often taught in a theoretical manner by academics who are not familiar with current industry practices. There is therefore a need for a mentorship programme linking undergraduate students with industry practitioners. Such a programme would guide students through a practical project that would include a design and verification/qualification phase. The project would likely take place over a number of months during the

university year, culminating in the semiconductor version of a residential weekend 'hackathon'. The goal of this programme would be for more students graduating with electronics degrees to move into IC design, rather than electronics, firmware or software design.

WE RECOMMEND THAT THE GOVERNMENT CO-FUND, WITH INDUSTRY, A MENTORSHIP PROGRAMM.

4. **Post-Graduate Training Courses**

Universities provide higher education to ensure graduates have the underpinning knowledge and understanding. There will always be a 'delta' between the output of higher education and the expectations of a specific sector like IC design. Currently, these needs are often addressed in an hoc and sub-optimal way. Therefore, we recommend creating a formal skills 'academy' to provide a coherent and focused way of closing the skills 'delta' for ab initio graduate IC designers. This academy would deliver practical training courses, focussed on the teaching the tools and techniques required for IC design, to supplement undergraduate learning. It should be a collaboration between, the Government, universities and industry, in order to ensure employers' needs are met and expert insight and support is provided by experienced practitoners. In this way, the effectiveness and professionalism of these new IC designers would be increased. There is also the possibility of use the academy to 'cross-train' graduates from related disciplines via a conversion course in order to increase the number of new IC designers entering the industry.

WE RECOMMEND THAT THE GOVERNMENT SUPPORTS AND CO-FUNDS AN INITITIAVE TO CREATE A FORMAL SKILLS ACADEMY FOR SEMICONDUCTOR IC DESIGN

LONG TERM

5. **Curriculum Change**

The only way for UK semiconductor industry to sustainably grow and thrive in the long term is to increase the number of students studying electronics at degree level. To achieve this, the UK must ensure that students are exposed to electronics throughout their educational journey (see Appendix 3 for current statistics).

The good news is that STEM is now prominent in media, education, industry and government. Unfortunately electronics is the 'hidden' part of STEM. Electronics has not benefited from the new focus on STEM and, until now, has not been a priority to government or educators. Indeed electronics is a relatively expensive subject to teach given the need for hands-on equipment; in recent years, the stagnation in funding for schools, and the resulting squeeze on budgets, has resulted in some schools cutting their electronics programs rather than investing in them.

UKESF (UK Electronics Skills Foundation) is an organisation founded in 2010 by a team originally led by Indro Mukerjee, the current CEO of Innovate UK. UKESF is dedicated to encouraging more students to study electronics, as well as ensuring that those studying electronics stay in the sector upon graduation.

Given that it is a micro-organisation, UKESF does an exceptional job of delivering practical programmes that touch a wide range of students and undergraduates. However, UKESF's activities are limited by budget constraints, therefore the organisation cannot fully realise its vision of communicating with diverse students, at scale, which would ultimately have a positive long term impact on the number of students who study electronics.

WE RECOMMEND THAT THE GOVERNMANT FUNDS AN EXPANSION OF THE UKESF'S PROGRAMME TO ENABLE THE DELIVERY OF ELECTRONICS MATERIALS TO SCHOOLS TO SUPPORT ELECTRONICS AND SEMICONDUCTOR SECTORS. .

SUMMARY

The UK's semiconductor IC design community has been one of the world's leaders in technological innovation for decades. Its long track record of success has made the UK an attractive location for home-grown and international companies to establish IC design organisations. Unfortunately, the supply of skills does not currently match the growing demand. The following recommendations would help to close the supply vs demand gap:

1. IMPROVE VISA PROCESS/COSTS.
2. INTERNATIONAL OUTREACH.
3. HANDS ON MENTORING OF UNDERGRADUATES.
4. GRADUATE TRAINING ACADEMY.
5. ELECTRONICS INTO CURRICULUM.

Stewart Edmondson
MA MBA BSc CEng FIET CMgr FCMI
Chief Executive
UK Electronics Skills Foundation
Stewart.Edmondson@ukesf.org

Attachments:

1. About the UK Electronics Skills Foundation
2. The UKESF Programme.
3. Acceptances from UK Domiciled Students on Engineering & Computer Science Degree Courses 2012/2021

About the UK Electronics Skills Foundation

The UK Electronics Skills Foundation (UKESF) is an educational charity established in 2010. In the UK, Electronics, especially semiconductor design and manufacture, is a growing and strategically important sector of our economy. However, the demand for capable graduates far outstrips supply.

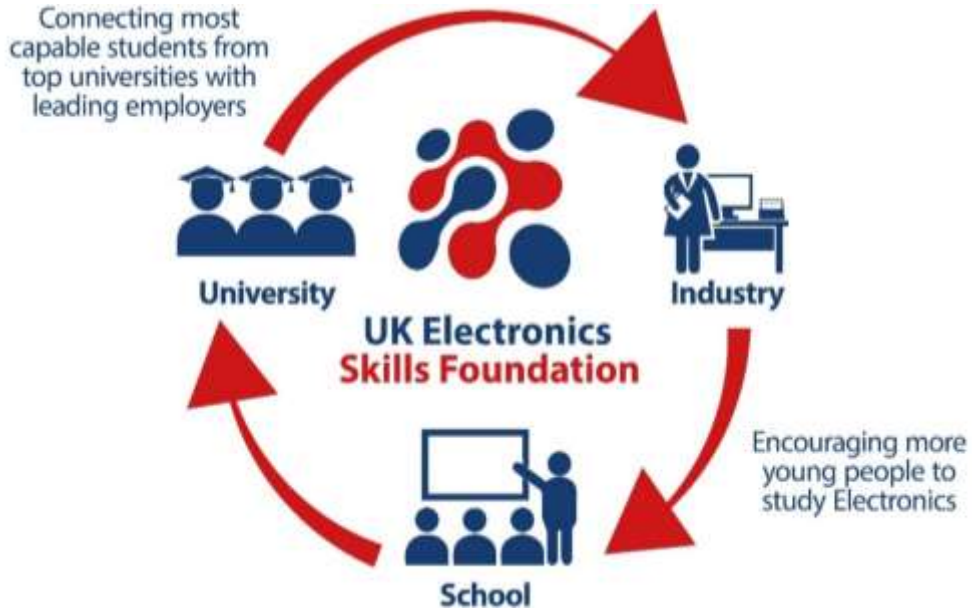
The UKESF works to tackle this national skills shortage in a coherent way; it operates collaboratively with major companies and leading universities. The UKESF also undertakes outreach and engagement activities to ensure that more schoolchildren are aware of Electronics and the opportunities available. This is achieved through a range of education Electronics-focused activities, projects and teacher training.

At the heart of the UKESF is an undergraduate Scholarship Scheme. This training programme provides professional education, development activities and work placements with leading employers for students from universities right across the UK. The Scholarship Scheme is now considered to be an exemplar of effective engagement between industry and universities. It is the basis of the UKESF's wider collaboration between higher education, industry and schools.

"The UKESF is the body responsible for education and skills in the UK Electronics sector. We've been really impressed with the quality of people coming through their programme." Director Engineering Development, ARM

Registered charity number: SC043940

www.ukesf.org



"Moving beyond talk about the skills shortage to take positive action is what the UKESF is all about."
Stew Edmondson, CEO, UKESF

The UKESF Programme

Schools. At schools, the UKESF focusses on investing in and supporting teachers and raising awareness among pupils about Electronics. The ***Electronics Everywhere*** project provides re-usable classroom resources and trains teachers in their use. This allows teachers to deliver the A-Level curriculum for Physics and Computer Science in a more engaging and interesting way and so improves the learning experience for their pupils. With ***Insight into Electronics*** pupils are provided with step-by-step instructions and a guide, enabling them to develop their knowledge and understanding of microcontrollers and embedded systems. The aim is to ensure that Electronics becomes an integral part of the curriculum and remains forefront in the mind of students when considering undergraduate programmes. ***Girls into Electronics*** is an intervention to address the gender imbalance among Electronics students.

The ***Electronics Everywhere*** project was developed in collaborations with the University of Southampton's prestigious school of Electronics and Computer Science. The boards have been manufactured in the UK. To date, over 550 secondary schools have received the resources. Supporting materials, including videos, have been produced, and a teacher from each school has received online training. Feedback has been extremely positive:

- 80% of teachers rated the resources excellent or good as a teaching aid.
- Overall, 95% positive reaction from pupils that used the resources.
- 60% of pupils were more enthusiastic about Electronics after using the resources.

"The students were engaged as they have never experienced of this type of Electronics before. The results they get are fantastic." *Physics Teacher, Barton Peveril Sixth Form College*

"The board is a great teaching tool" Joint Head of Physics, Graveney School, London.

In Dec 2018, the ***Electronics Everywhere*** project received formal endorsement from the Royal Academy of Engineering.

The approach that we have taken for this project is to provide practical resources (pictured below) for teachers to deliver the Electronics parts of the curriculum. We have chosen functions such as "music mixing" that are interesting and allow teachers to link to other parts of the curriculum (e.g. wave theory). We have included experiments that provide a very visual to theory (e.g. Planks' Constant).

The bare PCB exposes all components, creating a link between electronics and applications in many consumer products, and allowing students to extend their curiosity, showing that electronics is not a mystery black box. Importantly, the project also provides CPD for teachers to increase their knowledge about Electronics and so inspire more young people to take up a career in the sector.

Each school supported by this project receives a classroom set of 10 circuit boards. These resources are fully packaged and are re-usable. We provide training for teachers and access to online teaching resources, lesson plans, guides and additional information.

In July 2021 we launched ***Insight into Electronics***, based on an initiative we developed in collaboration with Aston University. The launch received an astounding response from keen students in Years 10–13, with several hundred sign-ups over the summer.

"Truly thanks a lot for the Arduino kit, as it really helped me delve further into Electronics through the aid of the kit as I would otherwise normally not have been able to access such technology."

In a recent survey of pupils following the ***Insight into Electronics*** course:

- 89% said the online resources were either excellent or good.
- 93% said the kit was either or excellent or good.
- 88% said they felt more enthused by Electronics after using the kits.

"I now want a career involving Electronics!"

Girls into Electronics. Since 2012, the UKESF has been organising residential courses at our partner universities to provide pupils with a 'taste' of studying Electronics at university. In 2019 we leveraged our experience and connections to deliver a course specifically for girls, ***Girls into Electronics***, targeted at female Year 12 students (ages 16–17) who were studying for A-Level qualifications in Maths and Physics. The course at Royal Holloway, University of London (RHUL) was a huge success. In 2021, we held the course on-line with the support of Aston University and RHUL. Feedback from the 2021 virtual attendees was very positive, including:

"I am thankful for everyone who spoke on the course, the people who supported us and the kit provided to us as I learnt a lot from it! It was a refreshing experience and has really made me consider studying Electronics at university."

"I'd just like to thank everybody involved in this course. I honestly would have never thought of Electronics as something that I could do without this. Thank you so much!"

For 2022, we are planning a hybrid course with some content delivered on-line before and after an in-person day for the attendees, hosted by a UKESF partner university. We intend to hold 10 of these in-person days, across the UK.

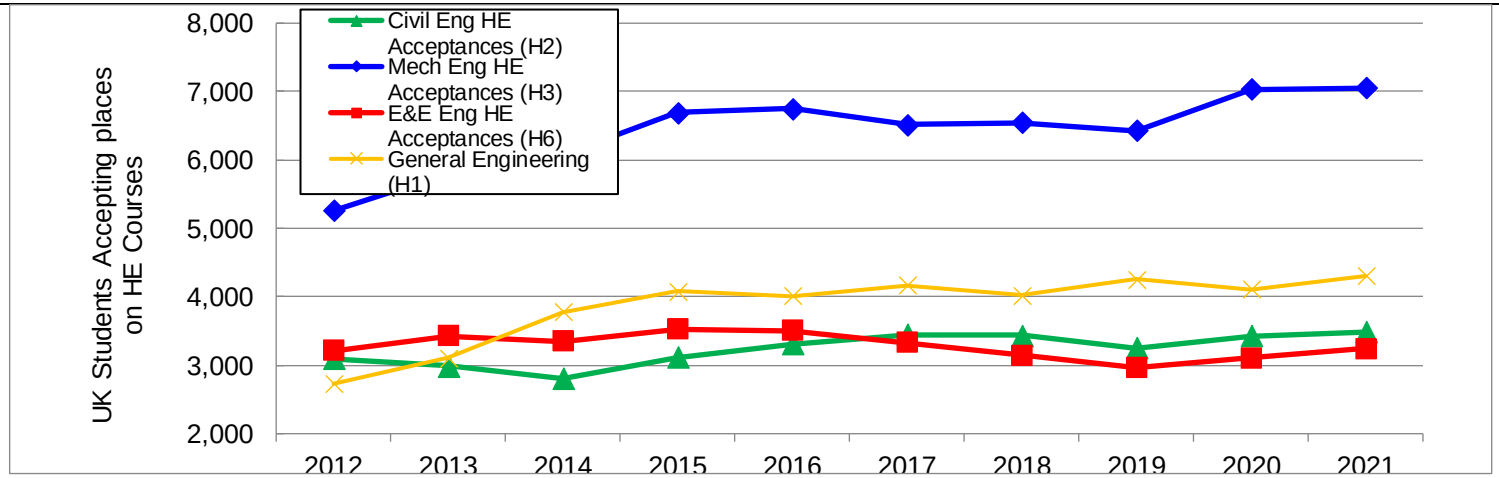
University. All engineering students are encouraged to undertake professional placements to complement their academic studies. These placements give students invaluable practical experience in a real work environment and are recognised as ways of further enhancing their career prospects. From an employer's perspective, placements are a great way to connect with potential graduate hires.

Scholarship Scheme. The UKESF Scholarship Scheme is a 'wrap-around' programme for Electronics undergraduates. The programme supports students, from advice about applying and increasing their employability through to graduation with an alumni network. The key elements are paid employment with their sponsoring company through flexible work placements; professional and employability skills training to complement their academic studies; industry insights and networking opportunities; and confidence building through participation in STEM education and outreach activities. is scheme provides a proven route for employers to connect with 2nd/3th year students 2020/21: Continued Success for Scholarship Scheme - UKESF. Since the scheme started, over 650 scholarships have been awarded and of those Scholars who have graduated, 94% are working in the Electronics/Technology sector and around 60% are working for a UKESF sponsor company.

Awards for First Year Students. This year the UKESF, in collaboration with the Driving the Electric Revolution Challenge, are launching a new initiative to raise awareness of Power Electronics, Machines and Drives (PEMD) among first year students at the UKESF's 26 partner universities. The DER Undergraduate Award will consist of a bursary and a one-off summer work placement with a PEMD employer. This initiative is based on an approach that we have successfully used for another scenario: Dialog Award for Female Undergraduates - UKESF.

Acceptances from UK Domiciled Students on Engineering & Computer Science Degree Courses 2012/2021[2]

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
All UK Domiciled Students										
Civil Eng HE Acceptances (H2)	3,100	2,990	2,805	3,115	3,315	3,450	3,440	3,255	3,430	3,485
Mech Eng HE Acceptances (H3)	5,260	5,800	6,070	6,690	6,750	6,515	6,545	6,425	7,030	7,050
E&E Eng HE Acceptances (H6)	3,210	3,425	3,350	3,525	3,510	3,330	3,150	2,965	3,105	3,245
General Engineering (H1)	2,730	3,110	3,780	4,085	4,010	4,165	4,025	4,260	4,115	4,305
Engineering HE Acceptances (H)	19,050	20,660	22,325	24,000	24,015	23,880	23,430	23,215	24,195	24,675
E&E Eng as % of overall	17	17	15	15	15	14	13	13	13	13
Computer Science HE Acceptances (I1)	11,190	12,820	13,825	15,410	15,700	15,620	15,430	15,110	15,975	15,765
UK Females										
Overall HE Engineering	2,245	2,415	2,990	3,510	3,685	3,755	3,840	3,915	4,035	4,240
E&E Eng HE Acceptances	225	240	265	280	310	295	305	255	290	335



[2] Data accessed from: UCAS Undergraduate sector-level end of cycle data resources 2021 | Undergraduate | UCAS