Continuous Education for RF Engineers to Meet Industry Requirement

This is a short article on the training of competent RF engineers for the electronic industry. It is well acknowledged that the demand for electronic engineering graduates that are competent in RF and Microwave technology is increasing in tandem with the growth in wired and wireless communication industries, and the reduction in product time-to-market.

Let us begin with the definition of RF engineers. We define RF engineers as [1]:
Engineers who need to employ some knowledge of electromagnetic (EM) fields or work with high frequency electrical signals, from VHF to millimeter waves.

This definition includes someone who:
- Works at circuit or chip level for amplifiers, oscillators, mixers, switches, antenna, filters etc.
- Works with analog RF signals at the system level.
- Works with digital PCB with mega to gigabits-per-second data rate.
- Enforces regulation or quality, such as electromagnetic compatibility (EMC).
- Works at device level (semiconductor or otherwise), such as material, transistors, diodes, waveguides, etc.

Let us take a case study on Malaysia. Malaysia has a large number of MNCs with strong requirements for RF Engineers. For example, (alphabetical order and non-exhaustive); Agilent, Altera, Avago, Epcos, Fairchilds Semiconductor, Huawei, Infineon, Intel, Laird, Mini-Circuits, Motorola, National Semiconductor, National Instruments, R&S, Sony, etc. Furthermore there are many smaller corporations which offer electronic manufacturing services (EMS) to these large MNCs.

Although the country has twenty public (from the Ministry of Higher Education website) and forty seven private universities (unverified source from Wikipedia), with at least fifty percent of them offering degrees in Electrical and Electronic (EE) studies, finding good RF Engineers is difficult mainly due to the following:
- Missing domain knowledge (knowledge gap).
- Piecemeal approach in the course delivery in the EE education.
- Sheer complexities of RF/microwave engineering theories; many students are put off by EM theories and mathematical knowledge such as vector calculus, partial differential equations, and complex analysis.
- Inability of young EE graduates to see the links between various domain knowledge and to use these effectively (This is certainly true for almost all the domains of EE, not only confined to RF/microwave).

In the argument above, it is clear that the main reason is the knowledge gap, which needs to be filled in order to address this shortage. To fulfil the knowledge gap for RF engineers, first and foremost we need to identify the 'basic' domain knowledge that is required of an RF engineer. A systematic approach is used to identify the domain knowledge by observing the various stages of a product development and the engineering tasks required in each of the stages. This is summarized in Figure 1[2].

Engineering Job Function \ Stages in RF Product Life Cycle	market analysis	product development	product characterization	test development	Assembly and fabrication	quality and reliability	sales and marketing	product integration
Application Engineer	✓						✓	✓
Technical Marketing Engineer	✓						✓	✓
R&D Engineer		✓	✓			✓		
Characterization Engineer			✓	✓				
Test Development Engineer				✓	✓			
Product Engineer					✓	✓		
Quality Engineer					✓	✓		
Process Engineer					✓	✓		
System Integration Engineer							✓	✓

Figure 1–Engineering tasks involved in supporting a product from concept to market[2].

Based on the job scope of the engineers in Figure 1, we identify the domain knowledge that is needed. This is illustrated in Figure 2[1].

Engineering Job Function \ Domain Knowledge with Examples of Subject Matter	RF concepts	Circuit design	Component design	Usage of EDA tools and simulation	Characterization of circuits /components	EMI/EMC, signal integrity	Usage of test & meas. instruments	Measurement automation	RF communication system concepts	Device and fabrication
	EM theory, transmission line, impedance matching, S-param. etc.	Filter, amplifier, mixer, oscillator, PLL etc.	Antenna, discrete, packaging, connectors etc.	DC, S-param., Transient, HB, EM, system	Small & large S-param., NF, P1dB, IP3, harmonics, bandwidth, gain etc.	PCB layout, controlling emission, distortion, crosstalk, signaling, probing etc.	VNA, Spectrum Analyzer, Signal Gen., DSO, Noise Analyzer etc.	Graphical programming, instrument interfacing, data analysis etc.	Transceiver architecture, link budget, radiowaves propagation etc.	RF CMOS, III-V Compound process, microwave transistors, diodes etc.
Application Engr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Technical Marketing Engr.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
R&D Engr.	✓	✓	✓	✓	✓	✓	✓			
Characterization Engr.	✓	✓		✓	✓		✓	✓		
Test Dev. Engr.	✓				✓		✓	✓		
Product Engr.	✓				✓		✓	✓		✓
Quality Engr.	✓				✓	✓	✓			✓
Process Engr.	✓				✓		✓			✓
System Integration Engr.	✓				✓		✓	✓	✓	

Figure 2 – RF domain knowledge for various engineering roles[1].

Looking at Figure 1 and 2, obviously it is almost impossible for a standard undergraduate EE curriculum to produce competent RF engineers that can meet industry requirements within a time span of four years. Universities need to balance essential engineering science and industry-specific domain knowledge, and we are of the opinion that universities should focus on the former. Moreover with only four years, students simply do not have the time to fully understand how instruments work, or the 'mechanism' of software tools and the practical aspects of using them. As it is, engineering students in most local universities are heavily occupied with many subjects, assignments, tests, and exams, not to mention the co-curriculum activities. It is unrealistic to expect students (or even faculty members) to effectively use instruments and design tools in a similar fashion as that of an experienced engineer. Thus, a system of continuing education, which involves the co-operation of universities, industry, and government, would be the best option to address the shortage of RF engineers. Such a system has already been in place within Malaysia for the past 6 years.

Essentially the system consists of **two** stages:

1. Universities equip potential RF engineers with fundamental science and knowledge.
2. Industry and government work together to provide focused professional training to jump-start the new engineers.

The salient features of this system are captured in Figure 3.

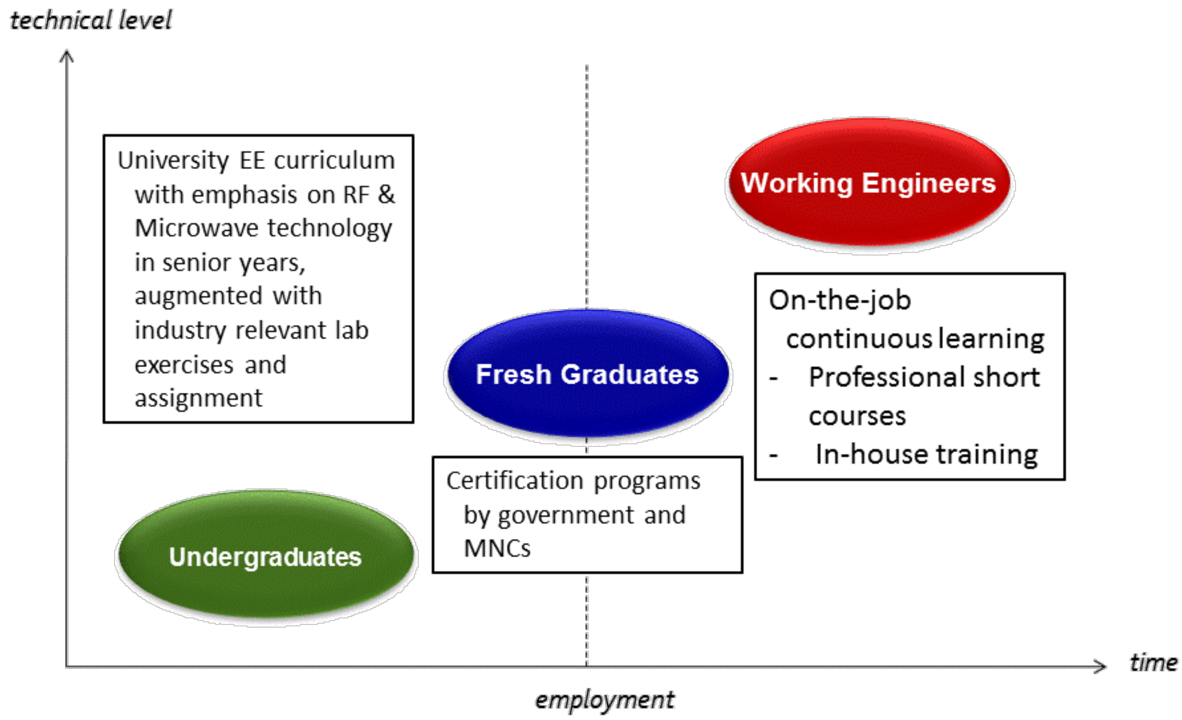


Figure 3–A system of continuing education to address the shortage of RF engineers in Malaysia.

An example of a special B.Eng Electronics with emphasis on RF and Microwave technology from a local university is shown in Figure 4[1], while a series of short courses and relevant certification programs offered by professional consulting firms are shown in Figure 6. The professional trainings highlight the real-world considerations by emphasizing on these:

1. Focusing on practical design/debug skills and design methodologies.

2. Familiarization with industry-grade tools.
3. Creating awareness on the economics of product development.
4. Provide an avenue to review theories learned in university with the aim of gaining a practical understanding and deeper insight into the knowledge.

The fourth point enhances an engineer's ability to link the various domain knowledge together with that are learned in universities.

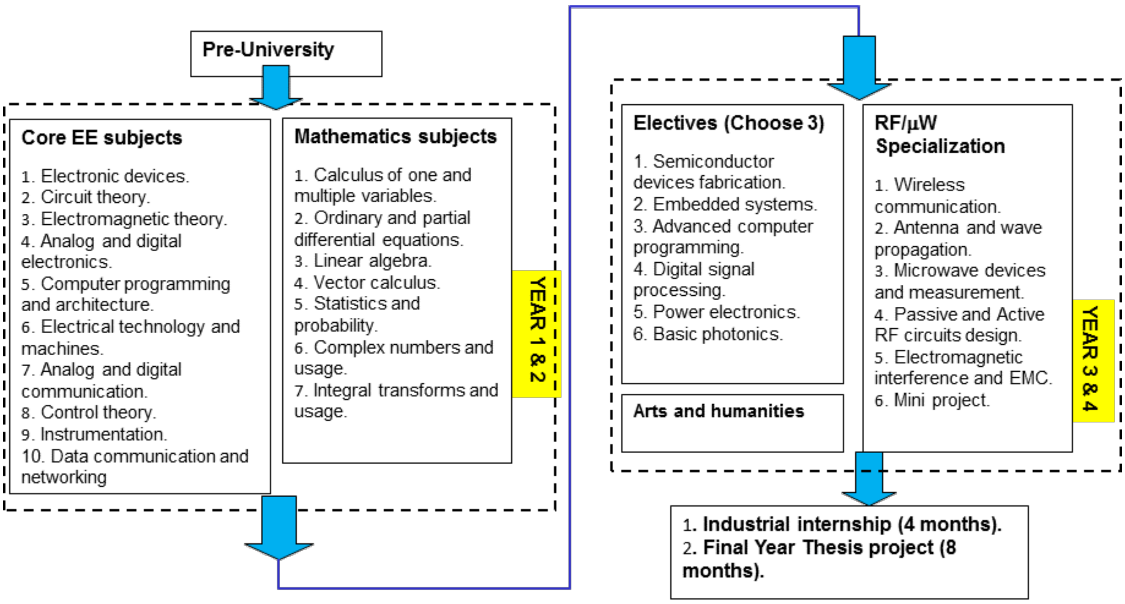


Figure 4 – B.Eng Electronic program with emphasis on RF and microwave technology ([1] and [3]).

Short course (2-4 days)

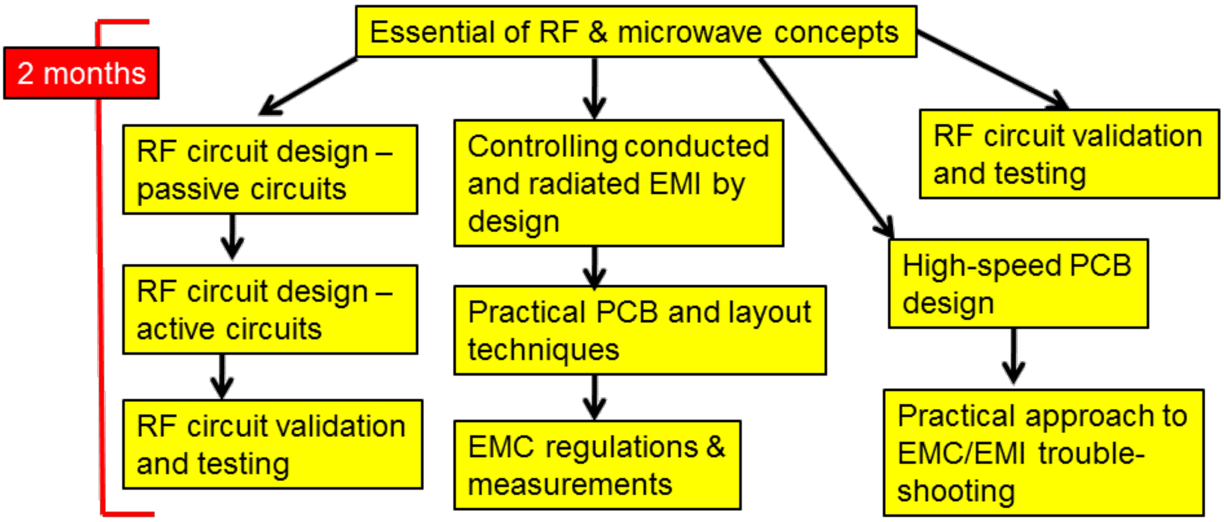
	SC	CP
RF circuit validation and testing	✓	
Essential of RF and microwave concepts	✓	
RF circuit design – passive circuit	✓	✓
RF circuit design – active circuit	✓	✓
Controlling conducted and radiated EMI by design	✓	
Practical approach to EMC/EMI trouble-shooting	✓	
Phase-locked loop and frequency synthesizer	✓	
RF circuit validation and testing	✓	
EMC regulations and measurements	✓	
Quick start to ADS (advanced design system)	✓	
Practical PCB layout and design techniques*	✓	✓
Practical antenna design	✓	
High-speed PCB design*	✓	✓

Certification program (4 – 6 weeks)
-Theories
- Tutorial
- Small project

*for certification program it is part of a module

Figure 5 – Short courses and certification programs.

Typically a professional training ranges from one to three months. An example of how the short courses can be mixed and matched to focus specifically on the RF and microwave industry is illustrated below:



References

1. F. Kung, W. H. Choo, V. C. Koo, " Educating RF Engineers for Multi-National Corporation in Malaysia", *IEEE International Microwave Symposium*, Baltimore, USA, June 2011
2. W. H. Choo, M. Kawasaki, F. Kung, "RF engineering education – the approach to bridge industry gap", *IEEE International RF and Microwave Conference,* Kuala Lumpur, Dec 2008.
3. http://foe.mmu.edu.my/v2/main/undergrad/, Faculty of Engineering, MMU.