The year is 1973, a young design engineer casually picks up a strangely marked piece of graph paper covered in an array of red and black arcs and circles, "what's this" he asks as he turns and speaks to the head of the microwave lab, "Ah that, that's the Smith chart" replies the older man; " it's a kind of map that we black magicians use to navigate around the underworld".

Forty years later that same design engineer has headed up an RF lab himself and, as he writes this review, still wonders why the idea of RF and Microwave engineering as black magic is such an enduring concept?

Much of the mystery surrounding RF engineering is surely down to the way it is taught; the simplicity and clarity with which dc circuits can be mentally visualized gives away to the seemingly strange and sometimes counter intuitive behavior of AC and RF circuits with no clearly defined boundary as to where one set of intuitions no longer applies and another takes over.

With this in mind, the most logical way to teach the subject would be to show that the same mental models can be applied to both DC and to RF circuits and to build the required visualizations in small incremental steps illustrating at each stage the steady transition from the DC case into the RF case using the power of modern software and simulation engines to create powerful visual models of circuit behavior.

In fact, this is exactly the approach that Dr Francesco Fornetti has taken in his most recent book entitled Conquer Radio Frequency which combines a lucid and smoothly progressive description of circuit operation as it transitions from DC to RF and combines it with powerful animations generated in Matlab and circuit simulations in AWR Microwave Office.

The book begins with the most fundamental concepts of electronics; current flow, voltage, resistance, electric and magnetic fields and underpins these concepts with the mathematics required for the subsequent chapters. The mathematics required for this step is very clearly illustrated with Matlab animations showing the graphical method of finding a function's derivative and a graphical demonstration of Euler's formula.

In the second chapter, the book quickly revises Maxwell's equations and then explores in detail the propagation of waves and pulses on transmission lines using the Microwave Office simulation engine to show the effect of line length and impedance mismatch.

In my view, one of the clearest way of demonstrating these effects to students is the use of a 'slotted line' test bench but of course this is a bulky and expensive piece of equipment and because of this it is rarely seen, however Dr Fornetti has overcome this problem by means of videos showing the reader how to construct a 'slotted line' simulation using MWO. This simulation along with some striking 2D and 3D animations created in MATLAB brings a really clear understanding of how transmission lines transform impedance and why 'standing waves' appear to stand rather than travel. Further videos show how to replicate the action of a Time Domain Reflectometer as an MWO simulation.

The quarter wave transformer is also demonstrated and discussed in this chapter and its use is covered for biasing narrow band amplifiers.

Having covered the theory underlying transmission lines, the book now moves on to discussions of commonly encountered real-world transmission lines such as coaxial and microstrip lines and considers how these can be designed and simulated in MWO and how the various physical properties such as dielectric loss and metal resistivity affect the electrical performance of the line.

The Maximum Power Transfer Theorem is also explained in this chapter through the use of MWO simulation and videos and its applicability to both the DC and RF cases is shown.

Chapter three moves on to consider the concept of reflection coefficient Γ and the effect of line length on the phase of the reflection coefficient and then introduces the idea of plotting the magnitude and angle of Γ on a polar chart thus leading into the ideas that underpin the workings of the Smith chart. Simple math is then used to explain the derivation and usage of S-Parameters, their application to Two-Port networks and the process by which the measurement of device S-Parameters can be transformed to the reference planes of the device itself despite the intervening cables that connect them to the measuring instrument.

As I mentioned in the introduction to this review, Dr Fornetti's approach to teaching RF engineering is one of smooth progression through the fundamental concepts with each step illustrated by use of industry standard simulation tools or animations generated with Matlab so one of the very significant benefits of this book is that, in addition to receiving a first rate understanding of the foundations of RF engineering, the student is also building an excellent hands-on knowledge of Microwave Office at the same time. As a result of this approach, by the end of the book, all the basic theoretical skills will have been acquired for everyday work in an RF lab.

This method of teaching really comes into its own when dealing with what many beginners perceive to be the darkest and most magical of the arts of RF engineering: Impedance Matching. This chapter has no less than 14 videos to illustrate both the formulaic and graphical approaches to lumped and distributed element matching. Combined with the handy tables of formulae for parallel/series and series/parallel conversions and the simulations showing current and voltage relationships for the equivalent circuits, the descriptions in this chapter really should remove the mysteries of impedance matching for the newcomer once and for all. I might add that although the greater part of this chapter is devoted to lumped element matching, the same level of clarity is also applied to the use of distributed elements and the transformations that relate them to their lumped counterparts.

The only thing that I would like to have seen added to this chapter is a brief mention of the Fano relationship between the Q of a device and the bandwidth over which it can be matched for a given return loss. Apart from this small criticism, I can honestly say that the way impedance matching is taught here is the clearest explanation of the subject that I have ever seen and this one chapter could easily stand alone as a small book or as a tutorial DVD in its own right.

The book closes with an introduction to Bipolar Junction Transistors, input and output impedance matching networks, Two-Port device characterization and the use and derivation of gain and stability circles.

Despite being a shorter chapter than the previous one, this chapter also has a comprehensive set of 10 videos to accompany it and should leave the reader with an excellent grasp of the causes of potential instability in high frequency amplifiers and the various ways in which it may be remedied.

Conclusion:

In my experience, the approach taken by Dr Fornetti in teaching RF engineering in this book is unique and the clarity of the text, the math and the simulations sets it apart from the other well known works such as that by Chris Bowick which address the same market.

The content of this book and the accompanying videos are comparable to a number of the expensive three or four day courses that are on offer but at a fraction of the price and with the added convenience that the student can study at his/her own pace and when work commitments permit.

All in all, I would say that, at this time, this book and its accompanying videos probably represent the fastest, easiest and most economical method by which a student can achieve a thorough grounding in RF engineering and, as a bonus, learn the use of one the most popular simulation engines along the way. I highly recommend this book to you.