PREFACE

I reread the preface of my first book [Bingham, 1988] and was very tempted to reproduce much of it here. The style and intended audience of the two books are much the same: both are something between an academic textbook and an engineering handbook and are aimed primarily at design engineers and programmers. The level of mathematics assumed is, for the most part, about first-year postgraduate, with only occasional excursions into more exotic realms.

The *and* in *ADSL, VDSL, and Multicarrier Modulation* is not precise; the scope of the book is wider than the intersection (a logic designer's *and*) but narrower than the union (a layperson's *and*). On the one side there are some types of multicarrier modulation (MCM) and some applications of it that are not covered, and on the other side some modems for the digital subscriber line (generically called xDSL) that are not covered; I have tried to provide enough references to take an interested reader further in those subjects.

The intersection—MCM used for the DSL—is a hot topic right now. Discrete multitone (DMT) has been standardized for asymmetric DSL (ADSL) by the American National Standards Institute (ANSI) as T1.413 and by the International Telecommunications Union (ITU) as Recommendation G.992 and may soon be standardized for very-high-speed DSL (VDSL). My hope, however, is that some of the material in this book will be general and forward-looking enough that it can be used—long after the glare of "Internet access" publicity has faded—to spur improvements in ADSL and VDSL.

These improvements should, as in all telecommunications, be backward compatible with previous-generation systems. Such compatibility will, however, be more difficult for DMT and ADSL because DMT was chosen and defined as a standard before the technology was mature. DMT is like the pianist Van Cliburn: heaped with honors early in its career and in danger of being chained to a metaphorical Tschaikovsky's Piano Concerto forevermore. The developers of DMT in the next few years could confine themselves to the receivers—thereby avoiding any problem of backward compatibility—but this would limit their creativity too severely. A better strategy (and a bigger challenge) is to develop better transmitters that are not so different from the standardized ones that they cannot economically be included as options, and are activated only when

connected to a compatible unit. G.994.1 defines an etiquette[1] for ''handshaking'' during the initialization of ADSL modems, which should allow for such future developments.

I have many ideas about these improvements, but since I am retiring I will not be able to work them out. I have therefore suggested them, and then used the term *unfinished business.* It is important to realize, however, that these improvements will not bring the increase in data rates that have been achieved recently in voice-band modems: a factor of 2 approximately every six years for the last 20 years or so. Despite their immaturity, DMT ADSL modems are probably operating within about 5 dB of the performance that is theoretically achievable under near-worst-case noise conditions. Improvements will come in the ability to deal with—usually to take advantage of—the widely varying levels of noise that occur in practice and in the practical matters of cost, size, and power.

During the discussions leading up to the adoption of the DMT-based standard there was intense intellectual and commercial rivalry between MCM and the more classical single-carrier modulation (SCM) methods. This rivalry, in which I enthusiastically participated, had the effect of discouraging—and in many cases preventing—objective discussion of the relative merits of the methods. I am retired now and can be a little less biased, but am probably still not yet far enough removed to write a completely objective comparison; therefore, I will try just to describe MCM, and mention SCM only when similarities or differences help to explain MCM.[2] The reader is referred to [Saltzberg, 1998] for an excellent comparison of SCM and the immature DMT as it existed in 1998. Whether his assessment of the relative advantages of the two methods will be valid as DMT matures remains to be seen.

One of the factors in the commercial and intellectual competition is the intellectual property (IP) owned by the competing companies, and patents are an important part of every engineer's library. I will therefore list all relevant patents that I know of, but I must make an emphatic disclaimer that I hope readers will empathize with: citing a patent means only that I consider that the idea has technical merit; it implies no opinion about the patent's legal validity.

DMT for ADSL was first developed at Amati, and was so successful that TI bought us in 1998. There was a rumor for a while[3] that in recognition of our contribution they would change their name to California Instruments, but alas, it was Amati's name that changed: AmaTI, then AmaTI, and now just TI[4]!

I am very pleased to have three contributors to this book: one collaborator on the T1E1.4 committee, Alan Weissberger, one ex-colleague, Mitra Nasserbakht,

[1] See [Krechmer, 1996] for a discussion of etiquettes and protocols as they operate in the world of standards.

[2] I will probably not be able to resist a chauvinistic comment from time to time, but I will try to confine them to the footnotes.

[3] I confess; I started it on April 1, 1998!

[4] The Amati family were the first makers of really good violins. There is no evidence that Stradivarius bought out Amati, but otherwise there is a close match.

and one group of ex-competitors from Aware Inc. They are experts in ATM, FFT implementation, and DWMT, respectively, and essential contributors to the overall MCM picture.

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