



# Advanced Arithmetic for the Digital Computer, Design of Arithmetic Units

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## Abstract

Abstract. Advances in computer technology are now so profound that the arithmetic capability and repertoire of computers can and should be expanded. Nowadays the elementary floating-point operations  $+$ ,  $-$ ,  $\times$ ,  $/$  give computed results that coincide with the rounded exact result for any operands. Advanced computer arithmetic extends this accuracy requirement to all operations in the usual product spaces of computation: the real and complex vector spaces as well as their interval correspondents. This enhances the mathematical power of the digital computer considerably. A new computer operation, the scalar product, is fundamental to the development of advanced computer arithmetic.

This paper studies the design of arithmetic units for advanced computer arithmetic. Scalar product units are developed for different kinds of computers like personal computers, workstations, mainframes, super computers or digital signal processors. The new expanded computational capability is gained at modest cost. The units put a methodology into modern computer hardware which was available on old calculators before the electronic computer entered the scene. In general the new arithmetic units increase both the speed of computation as well as the accuracy of the computed result. The circuits developed in this paper show that there is no way to compute an approximation of a scalar product faster than the correct result.

A collection of constructs in terms of which a source language may accommodate advanced computer arithmetic is described in the paper. The development of programming languages in the context of advanced computer arithmetic is reviewed. The simulation of the accurate scalar product on existing, conventional processors is discussed. Finally the theoretical foundation of advanced computer arithmetic is reviewed and a comparison with other approaches to achieving higher accuracy in computation is given. Shortcomings of existing processors and standards are discussed.

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# Digital Computer Arithmetic

**Christian Drosten**



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## **Table of Contents Digital Computer Arithmetic**

1. Understanding the eBook Digital Computer Arithmetic
  - The Rise of Digital Reading Digital Computer Arithmetic
  - Advantages of eBooks Over Traditional Books
2. Identifying Digital Computer Arithmetic
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals
3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Digital Computer Arithmetic
  - User-Friendly Interface
4. Exploring eBook Recommendations from Digital Computer Arithmetic
  - Personalized Recommendations
  - Digital Computer Arithmetic User Reviews and Ratings
  - Digital Computer Arithmetic and Bestseller Lists
5. Accessing Digital Computer Arithmetic Free and Paid eBooks
  - Digital Computer Arithmetic Public Domain eBooks
  - Digital Computer Arithmetic eBook Subscription Services
  - Digital Computer Arithmetic Budget-Friendly Options
6. Navigating Digital Computer Arithmetic eBook Formats

- ePub, PDF, MOBI, and More
  - Digital Computer Arithmetic Compatibility with Devices
  - Digital Computer Arithmetic Enhanced eBook Features
7. Enhancing Your Reading Experience
    - Adjustable Fonts and Text Sizes of Digital Computer Arithmetic
    - Highlighting and Note-Taking Digital Computer Arithmetic
    - Interactive Elements Digital Computer Arithmetic
  8. Staying Engaged with Digital Computer Arithmetic
    - Joining Online Reading Communities
    - Participating in Virtual Book Clubs
    - Following Authors and Publishers Digital Computer Arithmetic
  9. Balancing eBooks and Physical Books Digital Computer Arithmetic
    - Benefits of a Digital Library
    - Creating a Diverse Reading Collection Digital Computer Arithmetic
  10. Overcoming Reading Challenges
    - Dealing with Digital Eye Strain
    - Minimizing Distractions
    - Managing Screen Time
  11. Cultivating a Reading Routine Digital Computer Arithmetic
    - Setting Reading Goals Digital Computer Arithmetic
    - Carving Out Dedicated Reading Time
  12. Sourcing Reliable Information of Digital Computer Arithmetic
    - Fact-Checking eBook Content of Digital Computer Arithmetic
    - Distinguishing Credible Sources
  13. Promoting Lifelong Learning
    - Utilizing eBooks for Skill Development
    - Exploring Educational eBooks
  14. Embracing eBook Trends
    - Integration of Multimedia Elements
    - Interactive and Gamified eBooks

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