Chapter 7

PROCESSORS

INTRODUCTION

Theoretical investigations concerning quantum algorithms, automata, complexity, information theory and cryptography are of great interest and importance. However, progress in the experimental efforts to design quantum information-processing systems is crucial for seeing properly the overall perspectives of the future designs of real and powerful quantum computers, and for isolating and solving the problems that need to be dealt with if powerful quantum computers are ever to be built.

It has been realized, from the very early days of research in quantum computing, at least by some, that powerful evolution of isolated quantum systems is hard to utilize in real quantum processors, because of their interaction with the environment that can destroy very large but fragile quantum superpositions; and because of the natural imperfections of (inherently analogue) quantum devices. In addition, quantum error correction was considered impossible.

Fortunately, several developments brought the vision of quantum computers closer to reality. Quantum computation stabilization methods and quantum error correction codes have turned out to be possible and efficient. Techniques for fault-tolerant quantum computing have been developed. Finally, some promising technologies to design quantum gates, circuits, and processors have been identified and are being experimentally tested.

LEARNING OBJECTIVES

The aim of the chapter is to learn:

1. the early proposals for quantum computers;
2. the impacts of imprecision, dissipation and decoherence on quantum computing;
3. the methods of designing and using quantum error-correcting codes;
4. the basics of quantum fault-tolerant techniques;
5. the basics of the main current technologies used, or considered, to develop experimental quantum processors.