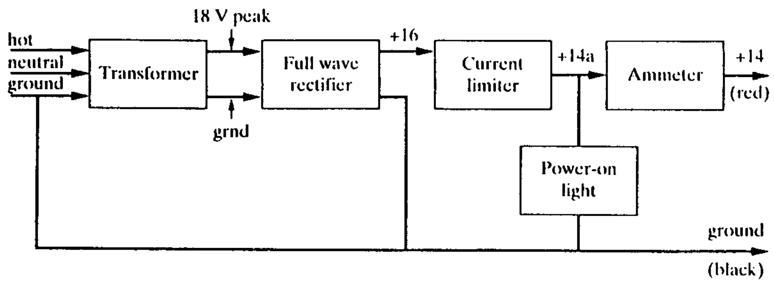

FIGURE 4.2 Block Diagram of an Automobile Battery Charger.

elsewhere, it is very important they be given meaningful names on the block diagram. Similarly, the wires that connect the blocks should be given meaningful names. Again, the names alone cannot convey the details of the signal carried by the wire. Usually the signals are also described in writing along with waveform diagrams. The description of "+14 (red)" output of the ammeter could include a waveform diagram like that shown in Figure 4.3.

The block diagram of the battery charger describes the original design problem as five smaller problems. The engineer has described the problem of designing a battery charger as the five problems of designing a transformer, full wave rectifier, current limiter, power-on circuit, and ammeter.

The block diagram evolves as the system design progresses. The first thoughts of the engineer will likely involve a rough sketch of a system

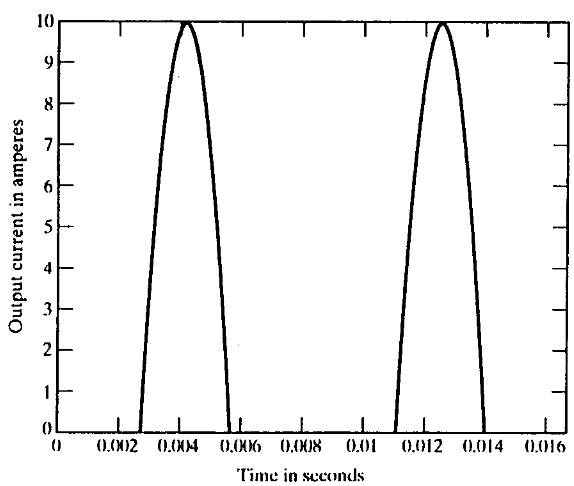

FIGURE 4.3 Current Supplied by the Battery Charger Versus Time.

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representing initial ideas for a possible solution to the design problem. The block diagram will be reformed and refined as the design is similarly refined. In this way, the drawing of the block diagram is tightly linked to the system design process. Later in this chapter, we will look at some of the techniques used by engineers for developing the block diagram. But first let us consider the system design process.

4.3 THE SYSTEM DESIGN PROCESS

As with all aspects of design, systems engineering follows the basic engineering process described in Chapter 2. Figure 4.4 provides an elaboration of that process, illustrating how the main concepts of synthesis, analysis, and iteration are applied to system design.

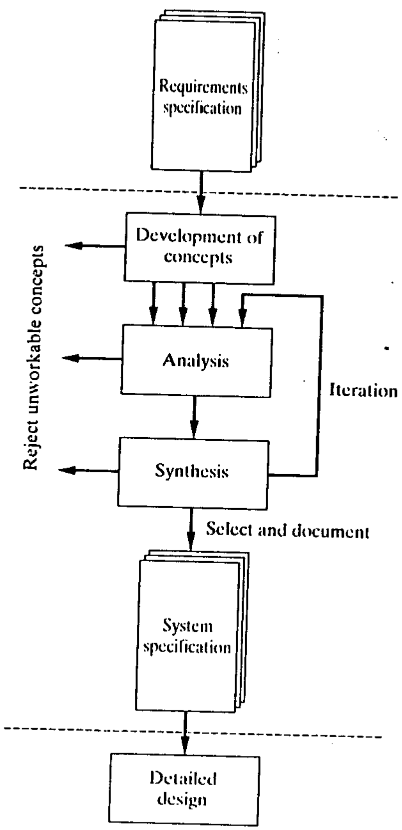

FIGURE 4.4 System Design Process.

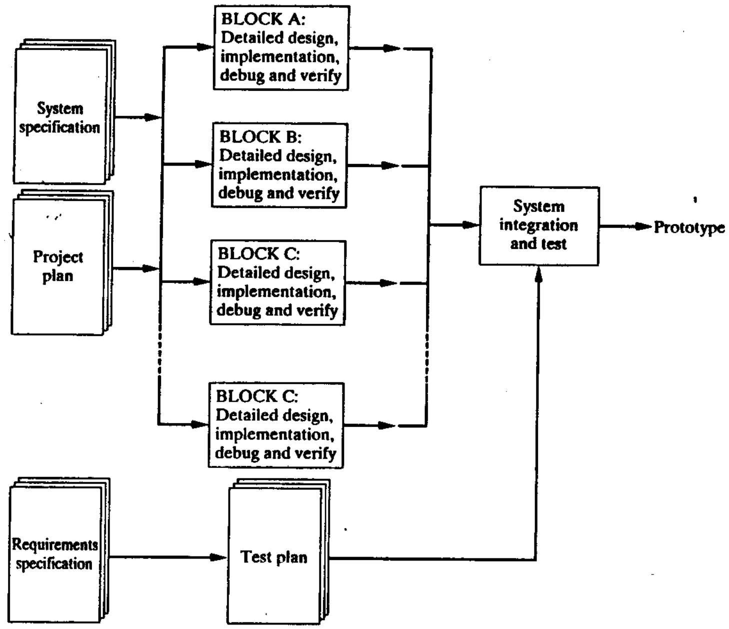

FIGURE 6.1 Activity Map Showing where Detailed Design and System Integration Fit into the Design Process.

block is to be started and finished and who is responsible for the design of each block.

The prototype is tested against the performance requirements listed in the requirements specification. These tests will determine whether or not the design is acceptable and, in the case of a contracted design, whether or not the customer will pay. For the design team this is like harvest time for farmers. There is the anticipation of reaping the rewards of their labor. At the same time, there are the "butterflies" that come with the apprehension of problems that the testing may uncover. Because of the importance of these tests, a detailed test plan is prepared in advance. To catch any incorrect interpretations of the requirements specification, the test plan is commonly prepared by an engineer who has had no prior involvement in the design. Where the design is being done under contract, acceptance tests will be performed by an impartial third party such as an independent consultant. The project plan will normally indicate when the test plan is to be prepared, who is responsible for preparing it, and who will conduct the tests.

Detailed design and the debugging of the proto-board or computer program will likely consume the majority of engineering resources expended on a design project. However, detailed design is dealt with only briefly in this book, as it is the primary subject of most other texts on engineering design. A typical college-level engineering program will have several classes covering circuit-design concepts and practices in a variety of technologies (digital circuits, RF circuits, etc.). It will also have laboratory assignments that investigate a few design tools (schematic capture and routing software, system and circuit simulators, hardware description language simulators, and synthesis compilers, etc.). While these courses do a good job of describing block design at a microscopic level, they often do not explain other important related activities like documentation and debugging. In this chapter, we complement this microscopic view with a discussion of where detailed design fits with the entire design process, and of the importance of documentation and debugging.

Block design and implementation can be broken into four activities:

Detailed Design In most engineering courses, detailed design is referred to simply as design. It is also commonly known as bottom block design. Detailed design of a hardware block means synthesizing a functional block with commercially available electronic components. Detailed design of an algorithm means writing a computer program. The thought process that produces the detailed design follows the design methodology described in Chapter 2, which was also applied at the system-design stage. The design is first synthesized, then analyzed, and then refined with synthesis/analysis cycles. The structure of a detailed design is represented by a schematic diagram or by a computer program. A schematic diagram is essentially a block diagram with the functional block being commercially available components.

Implementation Implementation entails building the circuit described by the schematic diagram. This activity is not required in the case of a computer program—implementation is done by a compiler. If their company is very small, engineers may build their circuits. In larger organizations, circuits are often constructed by technicians, perhaps with the help of unskilled labor.

Debug and Verification Debugging is an activity that removes errors in the design and mistakes in implementation. Most of the design bugs are removed during analysis. However, design mistakes like connecting an enable pin of a chip to ground instead of V_{cc} are usually found after the circuit is built.

After the circuit or program is debugged it is verified through testing. Testing is done to assure the circuit or program performs within the tolerance specified in the system specification. For example, if the block in question is an amplifier, it would probably be tested to see if the harmonic distortion is within specifications.

Debugging and verification are usually carried out by the design engineer, but are sometimes done by experienced technicians.

Documentation The importance as well as the extent of this activity is almost always underrated by engineers. Documentation produced during the