Design Process

5 Major Design Stages

1. Idea Generation (Problem Definition) ✓
2. Conceptual Design (->Preliminary Design) ✓
3. Detailed Design (Design Embodiment) ✓
4. Design Verifications (incl. Prototyping) ☛
5. Refinement/Final Design/Documentation which leads to production and marketing

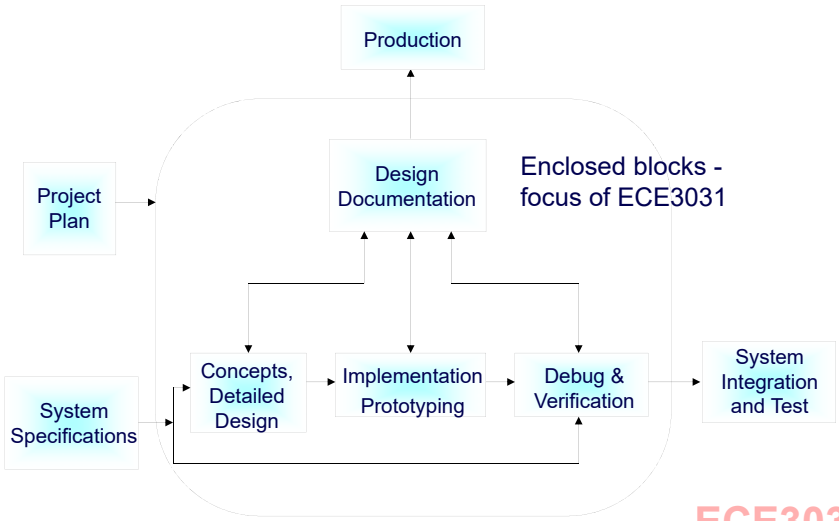
Design Verification

Design verification ensures that the product as designed is the same as the product as intended.

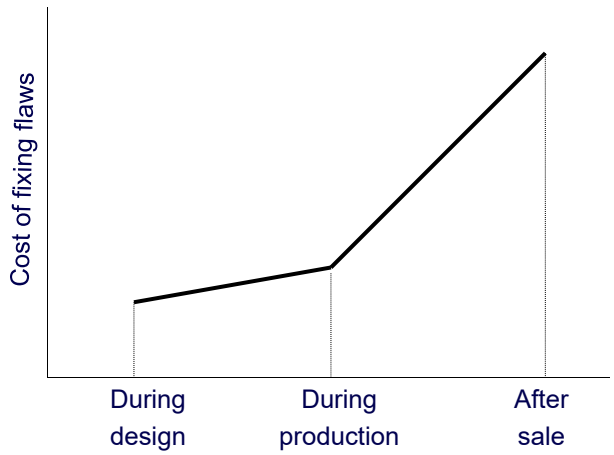
Design verification can be involved in several design stages/activities. Verification/testing may occur at many points during the design process, from concept development to post-production, as presented in the following activities/processes:

- Development of Requirements (technical)
- From Concept to Detailed Design
- From Detailed Design to Pre-Production
- Production and Post-Production

Verification as a Design Process



Early Detection of Design Flaws



Approaches of Verification

- Modeling and simulation studies
- Physical models: mock-up, scale model
- Testing (Types of testing)
  - Development testing is conducted with materials/parts, models or subassemblies. (for example bread board tests)
  - Prototype testing occurs with items that closely resemble the final product. (Your project)
  - Proof testing is designed to test the product to failure. These tests are often used to identify where eventual failures might occur. (Extremes, failures)
  - Acceptance testing is a form of non-destructive testing that occurs with production units. (samples) (burn-in)

Considerations in Selecting Verification Methods

- Cost
- Time
- Resources
- Degree of confidence (objectives)
- ==>May use more than one method (i.e. a combination of several methods)

Preparing Verification Activities

- Determining the best approach to conducting the verifications
- Defining measurement methods
- Identifying opportunities to combine verification activities (i.e., a single demonstration or test might be used to verify a number of requirements)
- Identifying necessary tools (e.g., equipment, software, etc.) and facilities (e.g., acoustical rooms, environmental chambers)
- Identifying verification schedules
- Design team and responsibilities
- Detailed verification plan (putting things together)

Conducting Verification Activities

- Execution of verification activities: follow the plan and procedures; get approval if modifications to the plan are necessary.
- Careful collection and recording of data: complete logbooks, verification of data recording
- Highlighting non-conformance: make sure that the non-conformance of the product is clearly identified; then details should be fed back to the designers as quickly as possible rather

Plan of Tests

RPM Monitoring Device (RMD): System Test Plan

1.0 INTRODUCTION

1.1 Overview of this Document

1.2 Conduction of the System Tests

1.3 Recording of Results, Witnessing, and Authorities

2.0 REFERENCE DOCUMENTS

2.1 Industry Standards

*Society of Mechanical Engineers, SME-37H41, Small Gasoline Motor Specifications, June 198, Section II.4, Spark Plugs.

*Automotive Industry Association, AIA-42.3, Gasoline Engine Design, May 1990, Ignition System Specification

2.2 Design Documentation

*System Specification, SS/06-02745-SP.1, Rev 2

*Block Level Diagram, BD/12-03190-GA.1, Rev 4

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*General Assembly Drawing, WD/02-03209-GA.2, Rev 0

3.0 RMD OVERVIEW

3.1 Operational Description

3.2 Definition of Terminology

3.3 Computation Methods

4.0 PRETEST PREPARATION

4.1 Test Equipment

*Frequency Counter PH417

*Oscilloscope Extron 523C

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4.2 Test Setup and Calibration

5.0 SYSTEM TESTS

5.1 Functional Checks

5.2 RPM Range and Accuracy

6.0 TEST RESULT ANALYSIS

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APPENDIX TEST RECORD SHEETS

Prototyping

Prototyping is an essential part of design, and an important approach of verification (demonstration and testing).

Prototype can be a full scale, full function product (pre-commercial version) or can be scaled-down version of products.

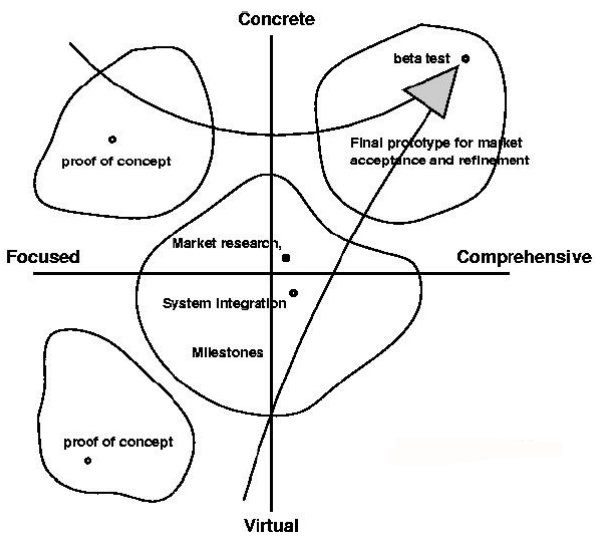
Virtual prototyping (software based): Computer-aided-design and computer-aided-engineering.

Physical prototyping.

Prototyping can be used in:

- Concept verification
- Design verification
- System integration
- Communications among groups

Types of Prototypes



Stages of Prototyping

- Almost all ideas and most products will need to be developed and verified through a succession of prototypes:
  - Initial proof of concept prototypes;
  - First product prototype. This is usually used to 'sell' the idea;
  - Market research prototypes;
  - Prototypes for testing/destructive testing;
  - Pre-production prototypes (beta test prototypes).

Initial Proof-of-Concept Prototypes

- Use the quickest, easiest and cheapest construction methods possible to prove that the concept is viable (ex: Lego-type blocks...).
- These prototypes will usually need to be repeated until you can make the product work and demonstrate your idea.
- They are usually constructed by the inventor. They should be thoroughly tested before being patented, or moving the to full scale development and design.

First Professional/Product Prototype

- Used to sell the idea to a licensee, to investors or potential major customers.
- Should attempt to determine the actual materials to be used, the tooling and production methods, and the aesthetics of the final product.
- Should use (or at least simulate) the chosen materials, should be largely operational, and should be as close as possible to "real product".
- Involve significant expenses, and professional designers, engineers, manufacturers and component suppliers

Market Research Prototypes

- May need a number of samples (or a small batch) to show potential consumers and key buyers in order to get their reactions.
- Aesthetic, ergonomic or customer appeal issues can be as important as the technical aspects of the product.
- Some of the Rapid Prototyping techniques can be used for short production runs using relatively inexpensive tooling.

Prototypes for Testing and Destruction Testing

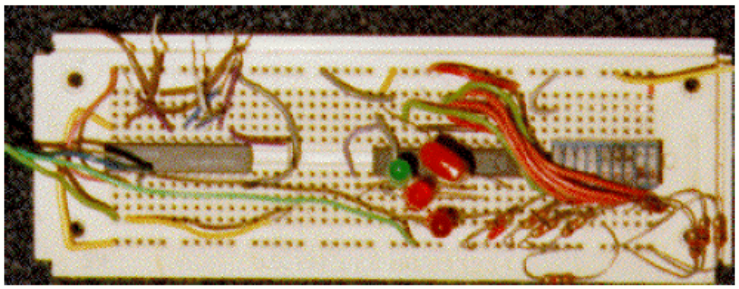
- Proof tests
- Assess the modes and consequences of failure if the product is overloaded, misused or abused
- Improve the design:
  - Redesign any components that are likely to fail;
  - Reinforce the existing design to strengthen components;
  - Select more robust materials for components;
  - Develop safety features to prevent situations of risk;
  - Develop safety features to minimize damage or injury caused by product failure;
  - Develop better instructions and warnings in manuals, labels and packaging; and
  - Allow for replacement parts where necessary if certain components inevitably have to wear out.

Pre-production Prototypes

- Confirm as far as possible every minute detail of the design, before committing to mass production;
- The pre-production prototypes should be almost identical to the version you will tool up for;
- Any adjustments made to the design during the construction and testing of these all-important prototypes must be fully documented and must find their way into your final engineering drawings;
- Up-to-date drawings/details are needed for ordering components and materials, for manufacturing purposes, for inspection and for quality assurance.

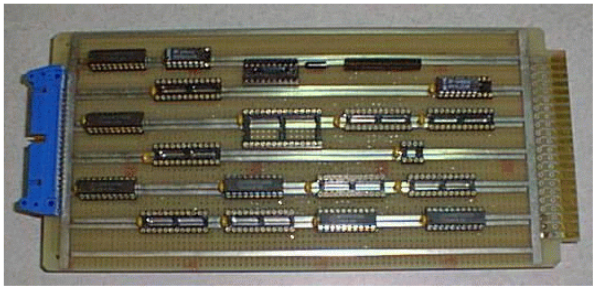
Some Commonly Used Prototyping Methods in EE Hardware

Bread Boards: inexpensive, fast, easy to modify; but unreliable, limited capacity, not for high frequency



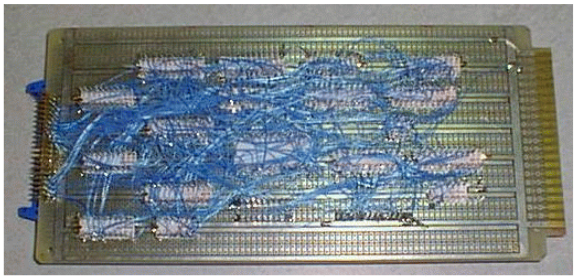
Proof of concept prototype

Wire Wrapping: comparable to breadboards but more reliable



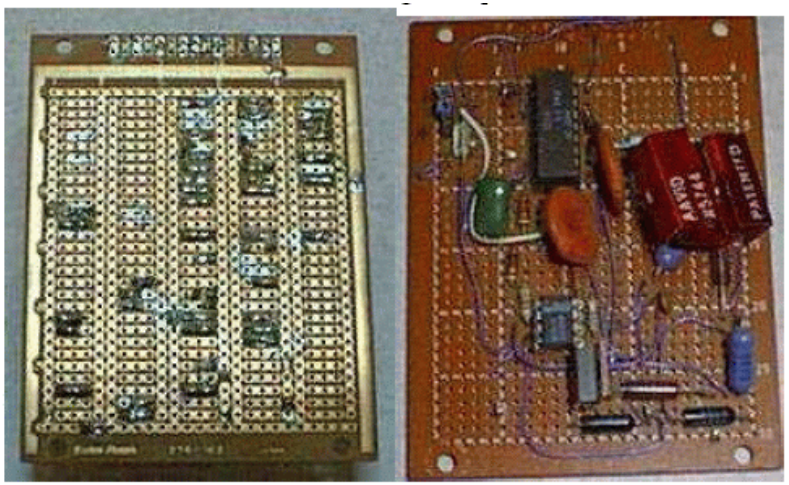
Wire-wrap board, top side

Proof of concept prototype



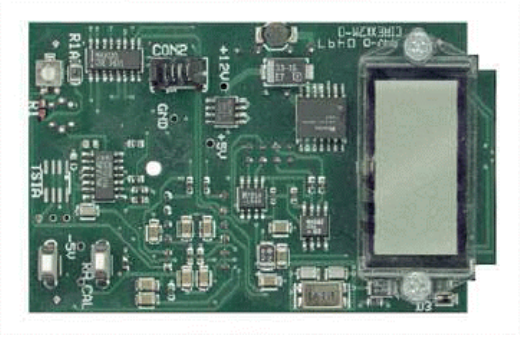
Wire-wrap board bottom side

Components soldered on general purpose PCB:
Reliable, inexpensive; slow process



Proof of concept prototype

Print circuit boards (PCB): reliable, easy to make;
expensive, long time in PCB design



Product/market research/testing/pre-production