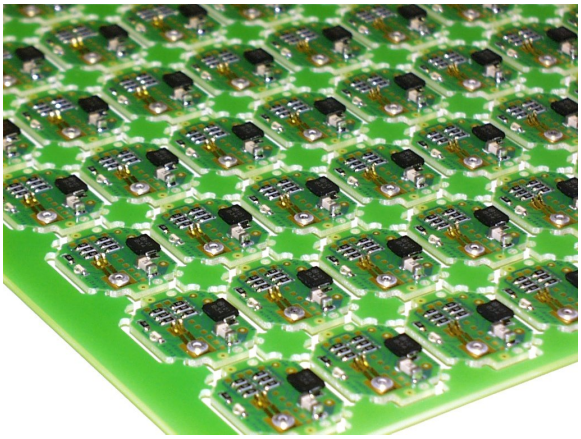
Production Volumes and Design Trade-offs



Different decisions are appropriate in the design of products intended for low, medium or high volume manufacturing.

NRE and BOM Costs

In the design of electronic products the effort expended on design is known as the non-recurring engineering (NRE) cost. For a commercial product this cost must be amortised across the subsequent production.

Typically, a trade-off can be made between the NRE cost and the bill-of-materials (BOM) cost of the final product. More effort expended in design can result in a cheaper product. How this trade-off is made depends critically on the volumes in which the product will be manufactured.

One-Offs

One-off devices are often created by artists, designers and hobbyists, but can also be found in industry performing process control, quality assurance and test functions.

For one-off (or very low volume) devices the NRE cost will typically be much greater than the total BOM costs since so few devices will actually be manufactured. It therefore makes sense to minimise the design effort as much as possible, even where this causes quite significant increases in the component costs.

A design choice that is typical in one-off devices is the use of off-the-shelf modules to provide much of the functionality, with minor customisation as required. For example, microcontroller boards such as Parallax Inc's BASIC Stamp modules or the open-source Arduino boards can provide control and interfacing functions. While such modules may cost tens or even hundreds of dollars more than the component cost of a bespoke design (because they may be overkill for the requirement or include functions that are not needed), this is easily recovered if even just a few hours of engineering time are saved.

Construction methods for one-off devices place little emphasis on assembly effort. For example, controls and switches may be connected by hand-assembled wiring looms, and printed circuit boards may be populated with both leaded and surface-mount components in a variety of different styles. Several different processes and much manual labour may be involved in assembling such a product, but this is not significant if only a few are to be produced.

Low and Medium Volume

Devices manufactured in low and medium volumes (from a few hundred to a few tens of thousands) represent the majority of products, from industrial and professional products through to the lower end of consumer products. For such devices the per-unit NRE cost and the BOM cost will often be comparable. The appropriate trade-off is the one that minimises the total.

Typically, most of such a device will be a custom design. For example, a custom circuit might be designed incorporating a suitable microcontroller and exactly those interfacing components required, rather than using a more expensive bought-in microcontroller board. The few days of engineering time expended represents a small per-unit cost when production volumes are significant.

However, bought-in modules are still used for functions that would take a large amount of engineering effort to develop from scratch. It is common to see bought-in modules performing

complex functions such as Wi-Fi or Bluetooth in these sorts of products.

Construction methods for medium volume devices place more emphasis on minimising assembly effort. For example, front-panel components may be mounted on the printed circuit board to reduce wiring. Boards are populated with a carefully controlled mix and placement of leaded and surface-mount components to reduce the number of process steps. For example, an all surface-mount board can use a single reflow solder process, or a mix of leaded on top and surface-mount on bottom can use a single wave solder process.

High Volume

Devices manufactured in high volumes (hundreds of thousands to millions) are almost always consumer products. For such devices the per-unit NRE cost is typically much smaller than the BOM cost since the NRE is amortised over such a large number of units. It therefore makes sense to expend design effort to reduce the BOM costs wherever possible.

For example, in a device incorporating a microcontroller it may make sense to spend significant design effort reducing the size of the software (perhaps even writing some of it in assembly language) in order to fit it into a smaller memory to save a few cents on the cost of the microcontroller.

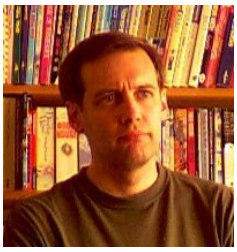
However, design effort is not unlimited. Although NRE cost may not be an issue, time often is. The limiting factor on the amount of design effort is often time-to-market. It is no good having a product that is cheaper than your competitors if they beat you to market by several months.

Design / Build

Like many electronic product design companies, Ionocom designs products that will eventually be manufactured in reasonable volumes. For one-offs, the cost of contract design usually cannot be justified. For professional and industrial applications where a one-off device is needed and the design costs can be tolerated, typically a "Design/Build" service is used. Clients should look for a company specifically offering this specialised service.

High volume devices are typically designed to minimise construction costs as much as possible. For example, significant design effort may be expended to get the whole design to fit on just one side of a PCB, using surface-mount components only, for a single reflow solder process with no secondary operations.

About the Author



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Prototypes

For designers who will eventually target medium volume production a common pitfall is to begin by developing a prototype as a one-off. Such a prototype may be useful to prove a concept or demonstrate it to investors. However, it will typically have little value in the subsequent development of the real product because it has been designed with all the wrong trade-offs. Before having a prototype designed make sure you understand what the intended purpose is. If the intention is to develop a product that will be manufactured in volume, and the concepts are well-proven and the required feature set is stable, then it may be better to simply proceed with development of the real product.