



RoweBots
Research Inc.

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Friendlier Appliances at

Lower Cost

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Introduction

User requirements are changing quickly for new appliances driven by more energy efficiency, environmentally friendly and cost conscious consumers. These same consumers perceive improved displays with color touch panels convey a message of quality and these same consumers always demand improved performance and reliability.

A major limitation of many manufacturers has been thinking about the myriad of design decisions for a new product by considering issues in isolation, or for a single product in the line without looking at the entire process of designing new products sequentially. A **systems approach** to design is required for optimal long term results. The designers can't think about individual designs, they need to think about a cohesive solution.

New requirements translate into new features and new implementation approaches for manufacturers. In order to deliver these new features while considering the process of designing lines of products; many manufacturers are migrating to lean product development or platform based development to spread costs over entire lines and multiple designs.

The lean product development approach focuses on the develops a basic platform for each line of products and targets specific components for incremental enhancement using various research and development programs. As enhancements are made they are introduced into the various products. Low end items get the older, inexpensive proven technologies with cost minimization while higher end models get innovative new features. This approach uses the same approaches automobile companies use to design cars.

Future Research and Development

Using lean development, the designers would first consider what each of the upgrades means in terms of changes to individual components across multiple units in the line, and then consider the effects that this might have on the aggregation of all modules.

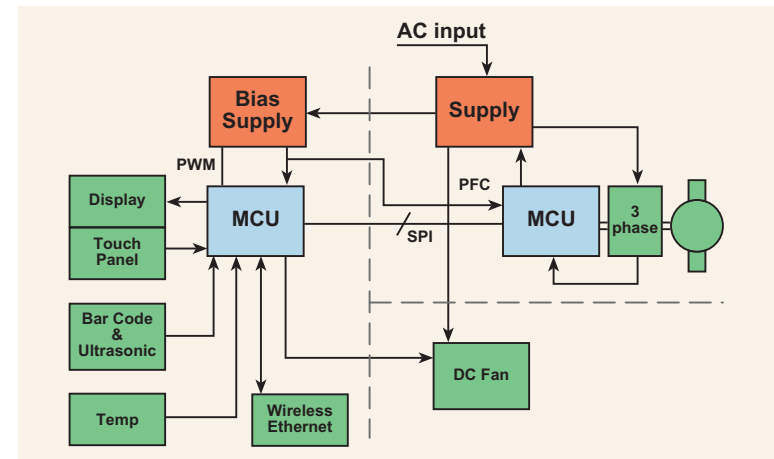
In practical terms, new environmental upgrades for a refrigerator would require:

- new coolant for refrigerators
- new compressor requirements
- new insulation
- and quieter operation.

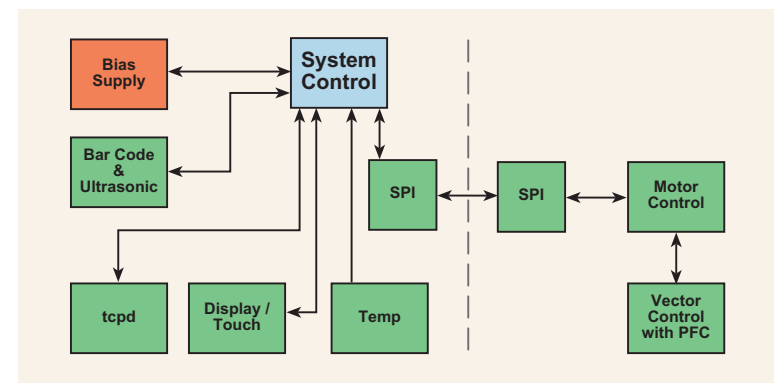
These features will slow global warming, something that certain consumers are willing to pay for. In research and development terms the components investigated would include: coolants, more efficient compressors to work with new coolants, new insulation and **new permanent magnet synchronous machine (PMSM) motor technology with Field Oriented Control (FOC) for the quietest, most efficient operation.** These new technologies would be introduced in high end models and migrate to the lower end over time as costs decreased with volume and margins could be preserved.

Display and Interface Upgrade features would recognize a need to have optional features with different price points with minimal cost. Color touch panels give the perception of quality, but also allow appliances to expand their information exchange. Mechanical switches and knobs can be completely eliminated if desired, and improved branding options are available at low or no cost using these new features.

EnerStar Upgrades would require improved efficiency utilizing many approaches like improved insulation, more efficient motors, reduced water consumption, power factor correction (PFC) and energy rate negotiation. As designers plan for these improvements, they must realize that these changes can require fundamental changes to the overall approaches taken.



A network connection is required for energy rate negotiation, PMSM motors with FOC require more compute power and color touch panel displays can offer additional new features like family message boards. This figure shows a version using two MCUs to provide the required features.



Future Research and Development

continued

Field upgrades can reduce field service costs, improve reliability and provide downstream revenue through the sale of add on components. Diagnostics can provide fast and simple service using network connections and provide fast and simple diagnosis of problems so the service person shows up with the right parts. Flash updates can improve algorithms for increased reliability as well as add completely new features. Power on self test can ensure the unit is safe independent of failed components.

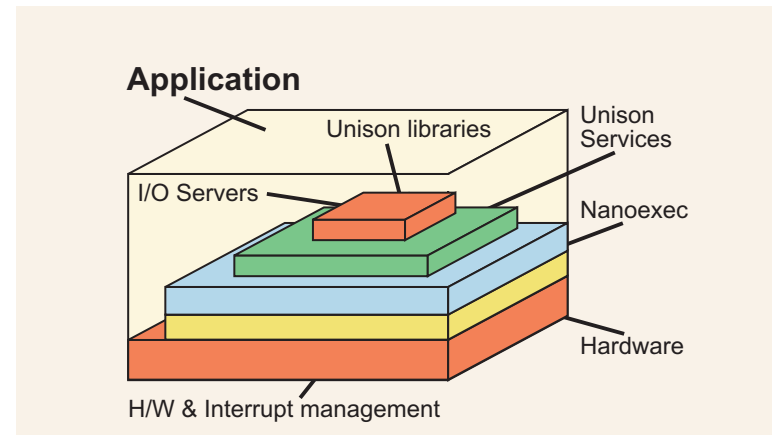
In many areas of the world, network upgrades for rate negotiation is expected. By utilizing the now required network in different ways as discussed above powerful new features can be added. WI-FI a natural choice for this communication link which offers simple secure setup and opens the door to remote service, remote upgrades and remote messaging.

A Unified Software and Electronics Approach

The means to implement a lean development program so that features can be easily swapped in and out and new features added without truly minimal cost is best supported using system on chip (SoC) microcontrollers (MCU) and a standards based real-time operating system. Today, the norm is hand crafted, difficult to maintain, difficult to upgrade single loops of control on absolutely minimal MCUs.

Standards based RTOS

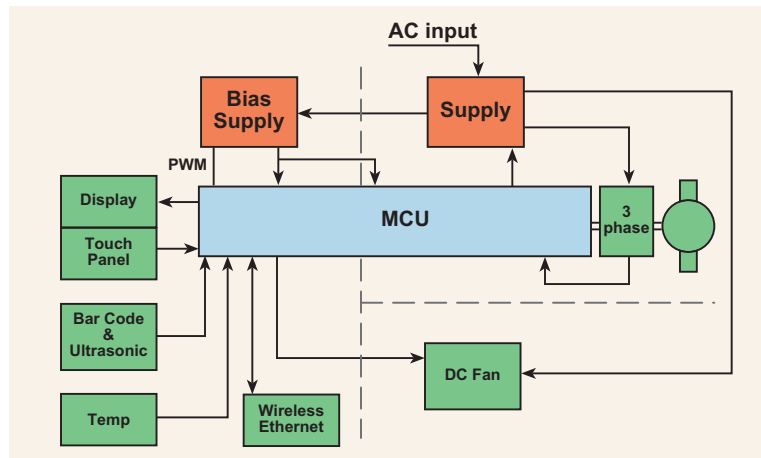
- *Use industry standard interfaces to maximize software life and minimize training and risk
- *Standard APIs support the use of standard I/O modules and interfaces to eliminate substantial development effort, eliminate training on sophisticated algorithms and slash development cost, maximizing profit.
- *POSIX with Linux is the only standard which is accepted around the globe.
- *DSPnano RTOS for 8/16 bit processors and Unison for 32/64 bit processors offer these standards and a broad set of off the shelf components.



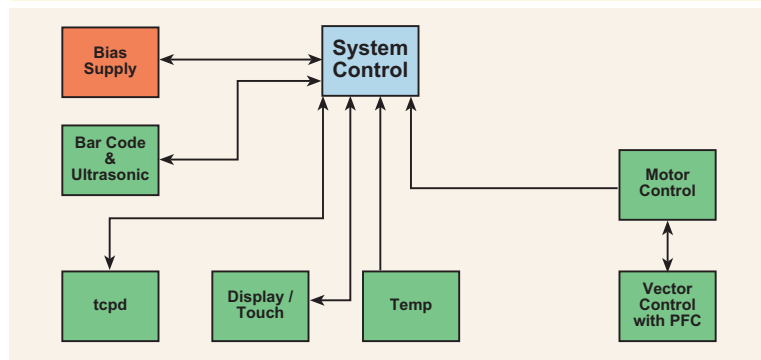
Consider the use of one or more MCUs connected via asynchronous serial lines for communication. If new features need to be added, the master controller requires a single serial port and a controller to implement the feature. In this way, costs and features can track the position in the product line.

Also consider the fact that a single powerful MCU is less expensive than a number of smaller MCUs. With either approach if the operating system applications programming

interface (API) is standardized, the effort to swap features in and out is minimal given underlying hardware support. With a more powerful MCU, products can also use the time based use of features to minimize overall MCU processing requirements making the system much more responsive. Of course, overall BOM costs must always be minimized to analyze these trade-offs.



By consolidating the multiple MCU implementation into a single MCU implementation with all software on the single MCU can sometimes reduce costs. The Software Architecture shows the modules spread out over several machines in distributed case and the central case with greater simplicity.



Software and Feature Transformation

To minimize research and development effort, a platform based approach requires a standards based embedded or real time operating system with a set of components to minimize development effort and speed time to market. The **DSPnano** and **Unison** operating systems offer Linux and POSIX compatibility on tiny MCUs along with a full complement of I/O, diagnostics, data logging and testing.

Using pre-integrated, tested and documented components drastically cuts development time. It is this class of off the shelf software that is key to realizing lean product development for appliances.

In all new energy and conservation based appliances, motor control with sensor-less FOC will provide quiet and maximum efficiency operation with maximum reliability through the elimination of halls and using a ramp start for minimal inrush current. From a software and hardware point of view this means more computation and more complex design with higher processing requirements; however, these software components can now come off the shelf.

Similarly, new display options and feature enhancements will eliminate mechanical rotating switches other than positional or on off switches. LCD displays, either B&W or Color with or without touch panels can be used across the line to minimize costs. Web servers will provide simple configuration of appliances. These interfaces require more processing power but the software components are off the shelf making development cost, time and complexity minimal. Of course, these off the shelf software components drastically cut time to market.

Software and Feature Transformation

continued

Networking is complex and involves a variety of protocols. It can include wide area networking as well as local serial networks such as multi-drop lines or USB. Without a wide area network, field upgrades via **USB** data sticks are a viable option. In addition power on self test, diagnostics and data logging are essential for field service and reliability. All of these features become software components and all are off the shelf in various forms today.

Using an operating system like Unison or DSPnano allows manufacturers to quickly realize new lines and new models. They provide portability and lean product development support. Both are Linux and POSIX compatible to maximize software life and minimize training and risk. They provide standard I/O modules and interfaces to eliminate training and development cost, include data logging for long term product improvement and offer power on self test and diagnostics.

Summary

The key to realizing new features and low cost for lines of appliances is a lean product development approach based on platform based design. Using networked SoC MCUs and a POSIX and Linux compatible embedded operating systems like Unison and DSPnano, manufacturers can slash development cost, risk and time while delivering advanced new features. Off the shelf features include: grid power negotiation networking, simple network and security setup via web server, data logging and diagnostics for remote service, color touch displays and remote messaging.

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