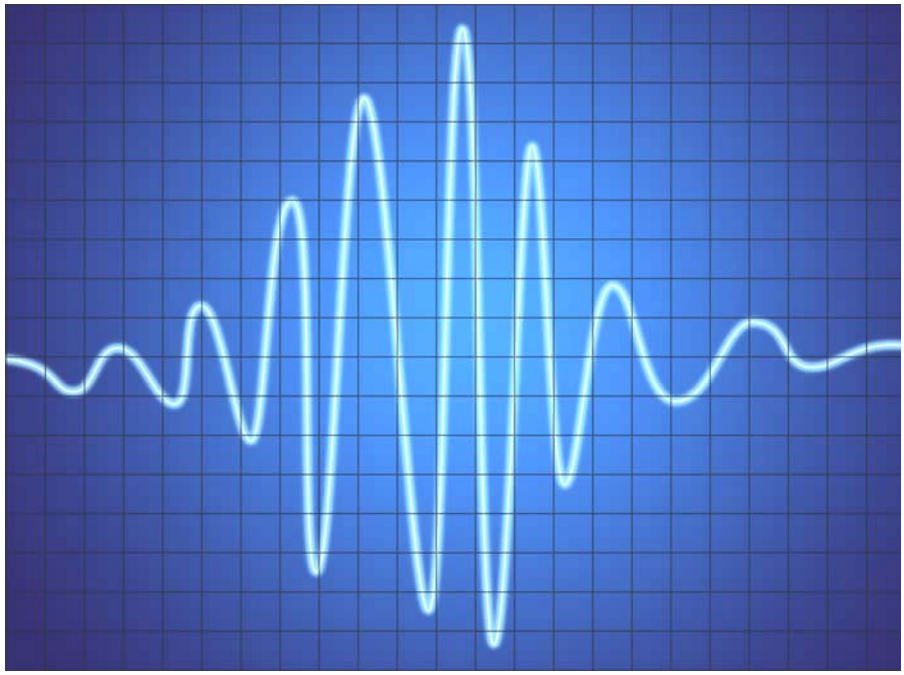

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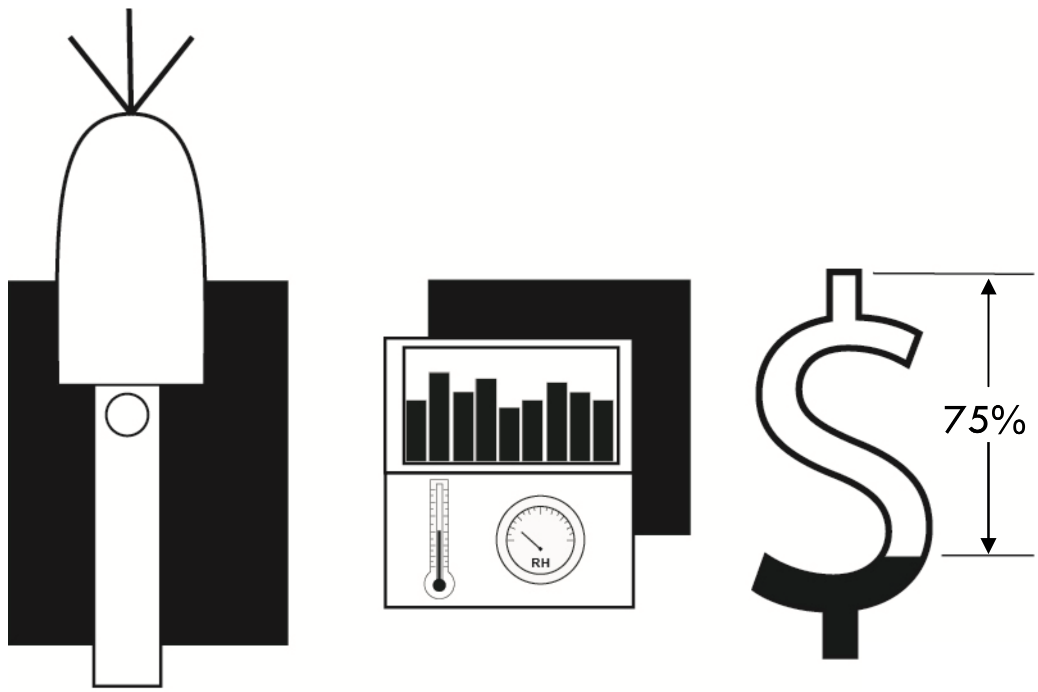
At Larson Davis, we recently completed the redesign of an outdoor preamplifier for our sound measurement products. Preamplifiers are used with our condensing microphones to reduce the extremely high impedance for transmission to signal analyzers. By using the Boothroyd Dewhurst DFMA® tool, we not only simplified the preamp design and optimized our part costs, we beat an aggressive cost-reduction target of 75% from the existing preamp cost. This paper shows how the DFMA® tool was used in our redesign to achieve these cost-savings and how far the cost reduction goal was exceeded.

Beating Aggressive Cost Targets with DFMA

A NEW PREAMP AT LARSON DAVIS

Many engineers anticipate the opportunity to start work on a new design project, especially when there are technical challenges. The euphoria quickly fades and turns into despair when it is learned that a seemingly impossible cost target has been set as a condition for market success. This was the situation for a group of engineers at Larson Davis, a division of PCB Piezotronics, Inc..

Larson Davis develops and manufactures equipment for monitoring and analyzing acoustic noise. One of these devices is a Sound Level Meter, commonly known by the acronym SLM. An SLM can be handheld, where it is subjected to shock and vibration, or mounted outdoors where it is exposed to temperature and humidity extremes. What makes a Sound Level Meter unique from other electronic recorders is that the microphone on an SLM is very sensitive and specialized for the application. The device that connects the specialized microphone to the SLM is referred to as a preamplifier, or preamp. A preamp reduces the extremely high impedance for signal transmission to the SLM, and Larson Davis also makes these preamps.



new preamp = existing preamp + new features – 75% cost

FIGURE 1 – NEW OUTDOOR PREAMP DEFINITION

THE DESIGN CHALLENGE

Product management charged the design team, with creating a new outdoor preamp. This design would not only replace a successful existing preamp but it would also add new technological features. These additional features were a new calibration check and an internal environmental control system, which allows the preamp to detect damaged, or out-of-calibration components and either automatically make adjustments to maintain in-spec sound measurements or notify the user of a problem while deployed in remote locations.

A material-cost reduction target of 75% of the existing preamp cost was requested for the new preamp design. Figure 1 shows the new preamp definition based on the existing preamp. An additional obstacle facing the new preamp development team was that two-thirds of the team members had begun working at Larson Davis within one year and had limited understanding of legacy Larson Davis preamps. The design team turned to Boothroyd Dewhurst's DFMA tool to meet the new design, aggressive cost target and limited team experience challenges of this project.

DESIGN CONCEPTS WITH DFMA

The design team utilized the DFMA® tool to familiarize themselves with the feature set of the existing preamp and create concepts for the new design. This procedure was accomplished systematically, resulting in an iterative, four-stage, process outlined below with the DFMA tool at its core. A flow chart illustrating this methodology is given in Figure 2.

Stage 1:DFMA Baseline

Using the DFMA tool to break-down the existing preamp was the first stage. The design team gained insight into the necessary components and features of the preamp. This stage also established the theoretical minimum number of parts and provided a Baseline DFA Index. Manufacturing personnel were heavily involved in identifying the assembly and logistics operations for the existing preamp. This input reduced the risk of production bottlenecks in the new design. The results of this collaborative analysis fed the second stage: Develop Concepts.

Stage 2: Develop Concepts

In Stage 2, the design team developed concepts to capture the defined feature count of the new preamp while minimizing the number of parts. The concept strategy that was emphasized involved optimizing the assembly by combining and simplifying parts. Once the constitutive parts of a concept were sufficiently defined in terms of geometry, function, and assembly, the concept was evaluated in Stage 3: DFMA Analysis

Stage 3: DFMA Analysis

Stage 3 involved the DFMA® Analysis of concepts developed in Stage 2 to obtain a quantitative comparison. Assembly time, material costs, and DFA index were evaluated for each concept. At this point, the concept details required further definition to determine feasibility.

Stage 4: Concept Feasibility

Feasibility investigations, such as tolerance analysis, printed circuit board (pcb) space comparisons, and strength characterizations were conducted during Stage 4 to validate the part reduction strategies used to create the concepts. The results of these studies influenced further refinement of the concepts pushing them back into Stage 2. The Feasibility stage and the Concept DFMA stage looped three times in our case as cost optimization converged. The project then transitioned into the traditional stages of design, prototyping, testing, documentation and release for production.

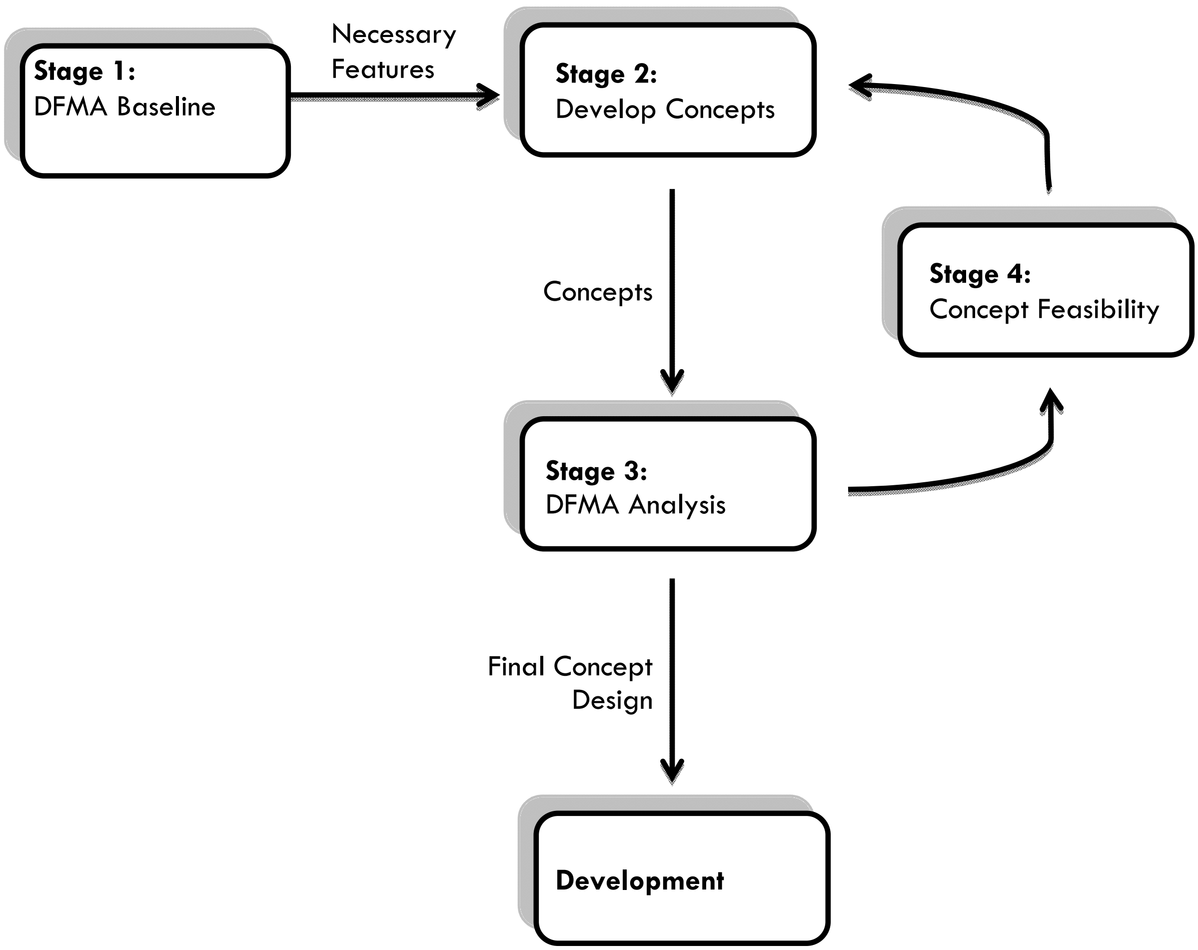


FIGURE 2 – DFMA PROCESS FLOW CHART

RESULTING CONCEPTS

The results of the DFMA® analysis for the new preamp are summarized in Figure 3 which illustrates the various concepts for a portion of the preamp design. The evolution of the design follows from Concept A to the final Concept D as the DFMA® loop is made. This last concept estimated a cost that was 21% below the defined target, with a 90% reduction in assembly time.

Concept A

13.6% Savings

11 Total Parts

Based on Existing Design

Concept B

29.2% Savings

10 Total Parts

Removed Reducer

Simplified Front-end

Not fully-constrained

Concept C

28.8% Savings

9 Total Parts

Expanded pcb Area

Changed Ground Contact (not shown)

Not Fully-constrained

Concept D

20.8% Savings

9 Total Parts

Added Snap-fit

Fully Constrained

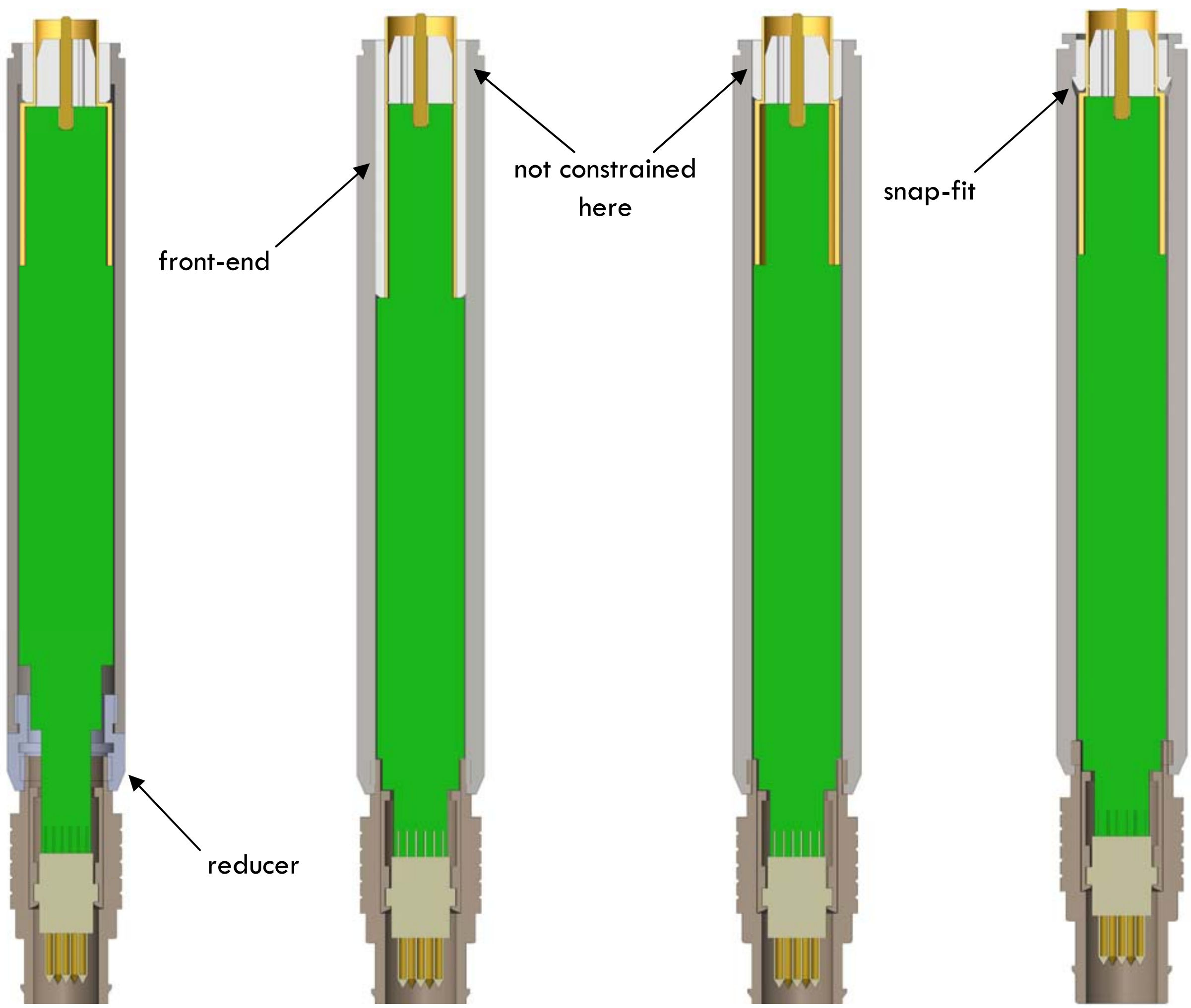


FIGURE 3 – COMPARISON OF NEW PREAMP CONCEPTS

HOW DID DFMA AFFECT DESIGN?

In order to achieve such optimal results with the new hardware design, a few key strategies were implemented:

- The two printed circuit board assemblies (pcbas) in the existing preamp were combined into a single, smaller, pcba. To reduce risk of the decreasing board area, the component density of other pcba was compared to the concept pcba as a feasibility study early in the project.

- Similarly, the optimum design concept pushed the features into a single housing. This allowed for a significant reduction in parts and assembly processes.

- Additionally, the geometry of the new housing was simplified using a snap fit of the outer insulator. This also contributed substantially to the reduced assembly time and part count.

- The elimination of fasteners in the new design was also key to reducing cost in this design. Although a majority of the original preamp fasteners were eliminated by removing other components, focusing on eliminating the number of different fasteners also yielded cost reducing results.

The design stages, used in conjunction with the DFMA® tool, allowed the team to meet cost goals. It also allowed for a significant decrease in part count and assembly time. Table 1 below shows the DFMA comparison of the existing preamp and the new preamp.

TABLE 1 COMPARISON OF EXISTING PREAMP AND NEW PREAMP CONCEPT

	Existing preamp	New preamp
Normalized Cost	100%	20%
Part Count	50	18
Assembly Time (min.)	75.7	7.2
pcb Assemblies	2	1
Fasteners	16	2
DFA Index	0.5	4.9

DFMA AS AN INSTITUTION

By using the Boothroyd Dewhurst DFMA® tool, the Larson Davis design team not only simplified the preamp design and optimized part costs, but they beat an aggressive cost reduction target by an additional 21%. An iterative methodology in the concept phase was the key to achieving these results for the new preamp. Larson Davis has institutionalized the DFMA® tool, and the iterative design concept methodology, into their process as a result of the success from this project.

ABOUT THE AUTHORS

Kevin Marett has worked as a Mechanical Engineer at Larson Davis for a year and a half. Previously he was part of the Mechanical Engineering team at QSI Corporation for 2 years. He recently received official recognition as a Certified SolidWorks Professional, was awarded a bachelor's degree in Mechanical Engineering in 2009 and just defended his Master's thesis in Mechanical Engineering from the University of Utah. Kevin has a keen interest in DFMA and eagerly distributes his knowledge with the other Larson Davis engineers.

Bill Devenish, a long-time DFMA advocate, has over 25 years' experience in technology product development. He is the Engineering Manager for Larson Davis where he institutionalized the use of DFMA. As manager of the MAD (Mechanical Advanced Development) Group at Harris RF Communications, Bill championed the use of DFMA by a team of design, manufacturing and sourcing engineers, who identified over $3 million in savings for one currently-shipping product in their first training session. While R&D Manager at Nokia, he led the team that developed the first smart phone released in North America in 1998, and has held senior management and engineering positions at QSI Corporation, AirNet Communications, NEC and Motorola. Bill earned a B.S. in Design Engineering from Brigham Young University, an M.S. in Management of Science and Technology from Oregon Graduate Institute and a graduate certificate in Systems Engineering from Florida Institute of Technology. He has been awarded ten patents and has authored several papers on DFMA, embedded passives, SolidWorks, and Design for Six Sigma (DFSS).