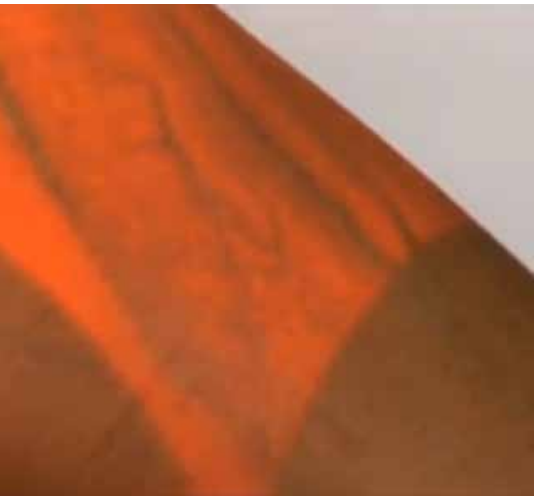

Case Study

Vein Viewer

Product Development

Product: AccuVein AV300 handheld vein finder

Application: Non-Invasive device to locate veins for blood sampling and other intra-venous procedures.

Group: Benchmark Electronics Design Engineering

Assignment: Take customer concept through complete engineering development process into a fully realized, manufactured, agency-approved, commercially available product, with full accessory set, manuals and packaging, for the health and medical industries.

The Challenge: Create an attractive, easy-to-use, hand-held, laser-based device that is safe yet able to locate difficult-to-find veins in the broad spectrum of human subjects and environmental conditions.

The Story

Our customer showed us a working prototype of their fascinating new medical device – a vein finder. Shine it on your arm and it actually made your veins appear on your skin. It provided an instantaneous non-contact image that was projected directly over the vein's location below the skin surface. Like a flashlight in the dark, moving it across your arm would light up new veins as the beam passed over them in real time. Other vein finders existed, but none were this simple, portable, or effective. This would obviously be a boon for those patients with small, deep or otherwise hard-to-find veins.

But there were performance inconsistencies from one prototype to the next. In addition, because the system projected both visible and non-visible laser light, it could pose a threat to someone's eyesight if a malfunction occurred, however unlikely. The time had come to introduce the rigors of a formal engineering development process. This is where Benchmark Electronics came in – to bridge the gap between a working concept and a real, marketable product.

Benchmark's product development process would capture all of the system's parameters. Knowing these would enable its performance to become controlled and reproducible, providing a path for design optimization. Engineering and manufacturing experts in all phases of the product's life cycle would be part of the process, ensuring a smooth transition from design to production. The Benchmark product design team worked closely with AccuVein to create what was ultimately dubbed the AV300, the world's first hand-held vein finder with real-time, pin-point laser-accuracy.

Development Activities

- **Industrial Design**
  - Market studies
  - Concept sketching / soft models / form-factor development
  - Accessory designs
    - *Charger*
    - *Device holders for hands-free operation*
    - *Carry case options*
  - User manuals in 32 languages
- **Human Factors**
  - User studies / Work flow analysis
  - Device and control suite ergonomics
  - User Interface design
    - *GUI navigation architecture*
    - *Audio feedback design*
- **Mechanical Design**
  - Detail design of housing, DFMA
  - Mechanical Design of Optical Engine and Scanning Mirror
    - *Shock mounting isolation*
- **Optical Design**
  - Laser projection and detection system
  - Scanning mirror system
  - Optical path alignment
- **Electrical/Hardware Design**
  - Electrical design optimized for low power usage
    - *Circuit design*
    - *Boards design and manufacture*
- **Software/Firmware Design**
  - Operating system / User interface
  - User PC Application
- **Prototype and NPI builds**
  - System integration
  - Prototyping / design validation / user testing
- **Design Verification Testing**
  - EMI/EMC
  - Laser safety
  - Agency liaising
- **Device and accessory labelling**
  - Complete packaging solutions for shipping
- **Complete assembly, test, configuration, & fulfillment services**
  - Functional test development for device and accessories
  - Automated assembly & test equipment design and build
  - Transfer to manufacturing

Conflicting Requirements

Performance requirements were broken into 4 quadrants: Reflection, Detection, Projection, and Protection – ***Reflection*** of Ambient Light, ***Detection*** of veins via infrared laser, ***Projection*** of that image with visible red laser, and ***Protection*** of the user and patient. Each quadrant could influence the other. For example, the greater the level of ambient light, the harder to see the projected image, but increasing the projected image strength might impact laser safety. Each quadrant had many parameters, adding complexity to the system's algorithms; factors included: amplitude and types of ambient light (fluorescent, sunlit, etc.), spot size and wavelength of the lasers, patient body type, their age, hydration level, skin color, surface texture, vein depth and size, etc.

A Real "Balancing Act"

Finding the "sweet spot" that meets the needs of all 4 performance quadrants, without conflicting with the desire to reduce the overall size and weight of the device, while extending its battery life and operating time, simultaneously enhancing its optical performance characteristics and robustness, all with an eye on manufacturability, cost, component availability and lead-times, at the same time squeezing the optimum performance from the technology, was a careful act of balancing ***needs*** with ***nice-to-haves.***

Heart of the System

Detail analyses and redesign of the laser guidance system (the “engine”) was undertaken – one aspect of this was durability. All handheld devices might be dropped, so this one had to be rugged to survive a drop and still work without any performance loss. Ruggedization was accomplished by shock-mounting the entire optical system to isolate it from the outside housing. This was helped by the reduction of design complexity: the overall optimized design reduced mass and size, and the number of parts for the optical engine were reduced by approximately 30%. Light-weight cast magnesium was chosen for the AV300 Optical Engine block.

To read more about the award-winning contributions a full-service outsourcing contract engineering & manufacturing partner can bring to a project, see *http://www.accuvein.com/bei/*

Industrial Design

Various form factors were explored, with emphasis on one-handed ease of use. Some of the questions asked early on by the designers were:

- ***How large are the users’ hands?***
- ***How should the device be oriented to the skin?***
- ***What grip pattern provides the best control?***
- ***How far away to hold from the skin?***
- ***What feedback sounds should the device make?***

Human Factors studies, sketching, soft modeling and rapid prototyping were employed to explore these options with users. Device center of gravity, colors, textures, proportions, button types, and user feedback were carefully explored to create a wholly professional medical device delivering an aesthetic, satisfying user experience that is not just useful, but attractive and useable.

Mechanical Development Challenges

Challenge	*Solution*
Form factor size/mass reduction	• Close packing of components and use of multilayer PCBAs
Resistance to water and dust ingress	• Labyrinth edges design on all housing parts • Use of elastomeric gaskets
Shock Isolation of optical components	• Mechanical suspension and vibration isolation to exceed drop shock requirements
Thermal Issues	• Full thermal simulation analysis of a AccuVein assembly • Design of decorative quality thermal heat sink band to safely dissipate heat with no openings to the outside

Problem Solved

The device houses 2 lasers: one invisible light for detecting the blood, the other visible red light for “painting” the image onto the skin. One of the use scenarios required an hour of continuous operation, but the lasers got too warm. Since the device was designed to prevent liquid or dust from entering the enclosure, open vents were ruled out for allowing heat to escape. The elegant solution was to integrate a wrap-around metal heat sink (affectionately called the “halo”) that would draw heat directly from the engine to the outside of the case. This was done in such a way to improve the overall look of the device while functionally providing the necessary thermal control. The “halo” was cast from light-weight magnesium; thermally conductive paste allowed it to dissipate heat without affecting shock mounting.

Programming the System

No less important was the system software / firmware. This work was done concurrently during mechanical detail design. Some of the challenges for the software team using CPLD hardware (Complex Programmable Logic Device) included the ability for field uploading microcode via USB, providing security to prevent use of counterfeit batteries, and embedding multiple language support on the device, selectable by the user.

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Focused Like a Laser

Towards the end of the design phase of the product and accessories, the team was able to move the project through NPI (New Product Introduction) and then smoothly into manufacturing. Custom automated and manual test and assembly equipment were also developed and installed on the production line. Application of a rigorous Engineering Development process, continually focused on the desired end goal, enabled the AV300 to become an exemplary, award-winning, attention-getting product.

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A great idea...

...needs a great medical design partner

The Benchmark Product Design Team worked with AccuVein® to create the **AV300**, the world's first portable, non-contact vein finder with real time laser accuracy.

Benchmark provided:

- Industrial Design
- HFE/Interface Design
- Mechanical Design
- Electrical/Hardware Design
- Software/Firmware Design
- Optics Design
- User PC Application Design
- Automated Assembly & Test
- User Manuals in 33 languages
- All Labeling and Packaging
- Full QSR Compliance
- Manufacturing Services

See the AccuVein® **AV300** Vein Illumination Device in action at *www.accuvein.com/bei*

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