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MarSum Solutions: Premier Partner in Ultrasonic Systems Engineering

MarSum Solutions is a premier engineering and consulting firm specializing in ultrasonic system development, with a proven record of innovation driven by co-founder Joseph G. Marcinkiewicz's 30+ years of expertise. Marcinkiewicz, an industry pioneer holding over 50 U.S. patents in controls and power, has led breakthrough developments in vibration welding, piezoelectric transducer control, high-frequency power electronics, and embedded real-time control systems. He contributed foundational technologies to Branson Ultrasonics' platform, including patented charge and force control methods for precision ultrasonic welders. This deep legacy of ultrasonic innovation underpins MarSum's ability to deliver cutting, edge solutions across a wide range of applications.

Figure 1- Example high-frequency welding press – representative of MarSum-supported systems.

Deep Expertise Across Ultrasonic Applications

MarSum's experience spans the **full spectrum of ultrasonic technologies** – from ultrasonic machining precision material removal to plastic and metal welding, ultrasonic actuators and motors, advanced sensing (e.g., sonar or NDT systems), and other high, frequency industrial processes. The core control and power electronic architectures developed by our team are broadly applicable, allowing transfer of knowledge across industries. For example, techniques originally devised for plastic welders can enhance ultrasonic drilling or cutting systems, and vice versa. MarSum's contributions have been production, proven in industrial settings – such as the Branson Ultrasonics welders whose control electronics were originally designed by Joseph Marcinkiewicz (now leading MarSum), and are relevant anywhere ultrasonics are used for manufacturing or automation. Our cross-domain know, how ensures that whether the goal is joining materials, machining hard composites, or enabling novel ultrasonic sensors, MarSum can architect a solution informed by decades of practical success. Importantly, MarSum brings cross, industry engineering strengths to every project. Our team has delivered high-performance systems in demanding sectors including **aerospace, automotive, and precision industrial equipment**, demonstrating that we can adapt and apply ultrasonic technology in diverse environments. This breadth of experience means we carry lessons learned and best practices from safety, critical aerospace controls, high, volume automotive production, and beyond – giving our partners a multidisciplinary advantage in their ultrasonic applications.

Advanced Control Solutions – AI and Model Based Design

Modern ultrasonic systems demand exceptional control performance and adaptability. MarSum sets itself apart with embedded AI and model, based control capabilities that bring ultrasonic machinery to the next level. We design intelligent controllers that actively learn and tune the process in real-time, ensuring optimal outcomes even as conditions vary.

Key differentiators of MarSum's approach include:

- **Adaptive Process Tuning:** Using smart algorithms, our control schemes will adjust parameters on the fly to maintain quality and efficiency. This means an ultrasonic welder can adapt to material or part variations automatically, or a cutting tool can optimize its vibration for different materials – reducing the need for manual re-calibration. MarSum's AI driven motor and actuator controls employ smart, adaptive control strategies" for precision applications, directly benefiting ultrasonic processes that require constant optimization.
- **Amplitude & Frequency Stabilization:** We implement dual closed-loop control to hold ultrasonic amplitude and adapt frequency setpoints, even as load conditions change. By leveraging accurate system models, our control methodologies can compensate for factors like tool wear or temperature shifts that might detune a piezoelectric transducer. The result is rock-solid vibration consistency for more reliable welding seams or machining precision. Stabilizing ultrasonic vibration amplitude is critical for process reliability, and MarSum's solutions achieve this through robust control design.
- **Predictive Anomaly Detection:** MarSum integrates predictive analytics to detect and diagnose issues early. Our methodology monitors subtle patterns in electrical variables, vibration feedback, and other signals to anticipate problems such as load jamming, tool detuning, or part misalignment. For example, a spike in drive power and phase shift might indicate an impending horn-tool decoupling; our methodology would alert or adjust before a failure occurs. This kind of predictive maintenance, essentially an AI-based "sixth sense" for the machine, minimizes downtime and enhances safety by catching issues that traditional methodologies miss. It's like having an

expert constantly watching the health of your ultrasonic system.

- **EMI/EMC Compliance by Design:** High-frequency ultrasonic equipment must coexist with sensitive electronics and meet regulatory standards. MarSum's engineers are experts in EMI/EMC modeling and mitigation, designing power electronics and enclosures that meet global electromagnetic compatibility standards. From filter design to shielding and layout, we build compliance into the control system architecture. Clients benefit from faster certifications (CE, FCC, MIL-STD, etc.) and trouble-free integration of our subsystems into larger equipment. Our experience in EMI/EMC ensures that the advanced digital controllers and high-power ultrasonic drivers operate reliably without causing interference or succumbing to noise from adjacent machinery.

Together, these AI-enhanced and model-driven control features enable ultrasonic systems that are self-optimizing, stable, and intelligent, far beyond the capabilities of legacy analog drivers or generic motor controllers. MarSum's focus is always on translating cutting-edge theory into practical reliability and performance gains for our clients.

Sensorless & Predictive Control for Ultrasonic Reliability

A hallmark of MarSum's approach is leveraging sensorless and predictive control techniques not as generic solutions, but as core enablers of advanced ultrasonic performance. Ultrasonic machines often operate in harsh or constrained conditions where adding physical sensors (like force gauges or displacement sensors) is impractical. Drawing on our deep background in motor control, MarSum has pioneered sophisticated sensorless algorithms that use electrical feedback (voltage, current, phase) to estimate mechanical impedance, and hence weld force, without a physical load cell with high accuracy. These algorithms, originally developed for high-performance permanent magnet motors, are now tailored to resonant ultrasonic systems, allowing us to precisely control vibration amplitude and force without dedicated sensors.

For example, our control firmware can detect the resonance frequency of a sonotrode and track it in real-time by monitoring the electrical impedance, effectively "listening" to the system's response and adjusting drive frequency for peak performance. Likewise, subtle shifts in current can indicate force changes during a weld; our sensorless force control observes these and modulates power to maintain the target force. The end result is consistent weld quality and actuator control achieved with elegant, robust designs – reducing complexity and points of failure.

Moreover, MarSum's use of predictive control means our systems don't just react quickly – they anticipate. By incorporating model-based observers and state estimators, our control techniques can forecast the system's behavior milliseconds ahead. In an ultrasonic cutter, this might mean predicting the tool's deflection on the next cycle and compensating preemptively. In an ultrasonic welder, the controller might project that the desired target displacement will be reached a few milliseconds early and taper the power to avoid overshoot. These predictive adjustments improve precision and protect the equipment from shock loads. We recast what might seem like "generic" advanced control into solutions finely tuned for ultrasonic applications, yielding superior reliability and performance. MarSum's philosophy is that the best ultrasonic systems "feel" alive – sensing their environment and adjusting continuously, and our sensorless, predictive control toolkit makes this a reality.

End-to-End Engineering

While MarSum was co-founded by two industry experts, we are far from a two-person consultancy. In fact, MarSum Solutions operates as a highly capable engineering partner with a deep, multidisciplinary team of experts ready to tackle every aspect of ultrasonic system development. Our team includes industry veterans, Ph.D.-level researchers, and patent-holding engineers who have delivered mission-critical solutions for Fortune 100 companies across multiple industries This collective expertise spans electrical, mechanical, and software domains – from power circuit design and transducer modeling to firmware development and mechanical integration

Crucially, we offer the capacity to handle end-to-end projects: from high-level concept and requirements definition, through detailed design and prototyping, to real-time control implementation and field qualification testing. MarSum can start with a blank sheet to architect a complete ultrasonic machine or subsystem, or seamlessly integrate into a client's R&D team at any stage of development. Our laboratory and workshop resources allow us to build and test prototypes in-house, accelerating development cycles. We also understand the certification and deployment process for industrial equipment, guiding designs through safety compliance (UL, CE, MIL standards) and environmental testing. When engaging MarSum, you gain a partner that can take an idea all the way to a validated product, reducing risk and ensuring coherence throughout the development lifecycle.

Moreover, MarSum's structure enables agility and scale. We can scale up for larger projects by drawing on a network of trusted specialists (for example, materials scientists or DSP experts) as needed, acting effectively as an extension of your organization's engineering department. This flexible yet comprehensive approach means even though we are a specialized firm, we bring the

depth and breadth of a much larger engineering team, ensuring no aspect of your ultrasonic project is beyond our capability. Our clients therefore enjoy both the personal attention of a focused consultancy and the broad competencies of a large firm.

Flexible Engagement Models for Collaboration

We recognize that every partnership is unique. MarSum offers flexible engagement models tailored to our clients' needs, ensuring we can contribute maximum value under various commercial scenarios. Some of our engagement options include:

- **Co-Development:** We work alongside your R&D team as joint collaborators. In this model, MarSum's experts integrate with your engineers to co-create ultrasonic solutions – ideal for companies seeking to augment their team with specialized ultrasonic knowhow while retaining close involvement. This accelerates development while upskilling your internal team through knowledge transfer.
- **Consulting & Architecture Design:** MarSum can serve as an architecture and design consultant, providing high-level guidance or detailed designs for ultrasonic product architecture, control algorithms, and hardware layouts. Leverage our experience at the project's outset to make foundational decisions (e.g. system topology, transducer selection, control scheme) that set the course for success. We can also troubleshoot and improve existing designs, acting as "critical friends" to refine your ultrasonic systems.
- **EMC/Safety Qualification Support:** For companies moving a prototype toward production, our team offers support in EMI/EMC compliance and safety certification. We help identify and fix EMI issues, prepare the technical documentation, and design for compliance with standards (IEC, FCC, UL, etc.). Similarly, we advise on functional safety, reliability testing, and other qualifications critical to deploying ultrasonic equipment in automotive or aerospace environments. This ensures a smoother path to market for your product, avoiding late-stage surprises.
- **Turnkey Subsystem Delivery:** MarSum is fully equipped to deliver complete ultrasonic control subsystems or prototypes as a turnkey solution. In this model, we take responsibility for a defined subsystem – for example, a 20 kHz power supply/controller for an ultrasonic welder, or a smart ultrasonic actuator module – and design, build, and validate it to meet your specifications. You receive a ready-to-integrate unit, designed with our best-in-class controls and electronics, reducing your development burden. We can also provide custom software/firmware and documentation as part of the deliverable. This is an excellent option for clients who want a fast-track solution leveraging MarSum's existing technology building blocks.

Regardless of the engagement style, our focus is on collaboration and knowledge sharing. We can adapt to evolving project needs – whether that means transitioning from a consulting role into a build phase, or vice versa. Indeed, our flexible approach guarantees that our efforts will add value even if priorities change during a project.

At every step, MarSum aims to spark innovation and drive progress for our partners, functioning as an extension of your team with the success of your product as our primary goal.

MarSum Solutions combines veteran insight with modern innovation to propel ultrasonic technology forward. We pride ourselves on a professional yet creative approach, always maintaining clear communication and a focus on deliverable results. For R&D leaders and innovation teams looking to push the limits of ultrasonic machining, welding, actuation or sensing, MarSum offers a unique partnership opportunity. We bring a history of success, a suite of advanced capabilities, and a readiness to deliver on even the toughest ultrasonic engineering challenges. Let's collaborate to turn your ultrasonic ideas into reality – with MarSum as your trusted engineering partner every step of the way.

Contact us today to scope your ultrasonic project!