Relevant Capabilities – Mide Technology

Mide specializes in low-power electronics and advanced data acquisition systems. We have created the enDAQ platform (https://endaq.com/), an end-to-end ecosystem for collecting, analyzing and distributing information from an assortment of remote sensors. Leveraging this ecosystem, Mide is able to enable complex custom data acquisition solutions within an attractive timeframe and budget. The enDAQ platform, including sensors, software stacks and optional cloud backend, are production (TRL9).

More recently, Mide has begun integrating wearable sensing and actuation capabilities into the platform, under the name CorBus (Corporeal Bus). Together, these developments support rapid development and deployment of end-to-end wearable sensing, alerting and communication applications.

enDAQ Platform (TRL9)

The enDAQ platform components consist of:

- Low-Power Sensor Packages: enDAQ sensor packages include standalone self-powered multisensory recorders and wireless nodes with recording and streaming capabilities. Current off-the-shelf devices include high-speed shock & vibration, sound, environmental (temperature, humidity, pressure), 9DoF orientation and location. However, a main benefit of the platform approach is the ease of developing custom nodes to support novel sensors, interface and form-factor requirements.
- Efficient Storage and Streaming Format: The extensible Instrumentation Data Exchange (IDE) format supports efficient storage and transmission of mixed multisensor data by low-power embedded sensors. Its features include flexible sensor description metadata for integration of novel sensors, and powerful post-hoc data transforms that offload calibration, linearization and other upfront processing from size- and power-constrained end nodes.
- Open Source Software: Several powerful data retrieval and analysis tools are available. The standalone enDAQ Lab GUI supports quick viewing , analysis and export of sensor data to other formats, while the open-source **endaq-python** (https://github.com/MideTechnology/endaq-python) provides a powerful development API supporting custom applications interacting with the enDAQ ecosystem and optional cloud services.
- Cloud Backend: enDAQ Cloud allows users to analyze, visualize & generate custom reports in a safe, secure AWS-based environment. enDAQ WiFi devices support direct upload to the cloud; available automation APIs and manual upload options provide flexibility for geographically distributed sensors and stakeholders with a wide variety of unique needs. The service supports powerful custom analysis, tagging, filtering and alert capabilities (e.g. geofence).

Wearable Integration – CorBus (TRL4-7)

Mide realizes that the innovations required to produce the next great smart textile are multifaceted, and will not occur at the same time or under the same roof. Using the same platform approach, Mide hopes to enable diverse innovators to come together to realize advanced smart textile applications responsive to the unique needs of first-responder and defense applications without unnecessarily reinventing the wheel. These include the need to remain comfortable over long multi-day mission durations, survive a harsh operational environment, minimize detectable RF emissions, and provide scalable manufacturing of many unique variations (sizes, thermal weights, materials, sensor loads) that remains cost-effective at small production volumes.

To this end Mide has developed several complementary technologies under the umbrella of "CorBus" (Corporeal Bus), as a sensor-agnostic e-textile integration platform, designed to solve challenges in the design, production and adoption of smart e-textiles. CorBus optionally bridges body-worn distributed sensor loads to the existing enDAQ end-to-end platform, as well as enabling time-correlated distributed sensing and realtime sense-respond and haptic cueing applications.

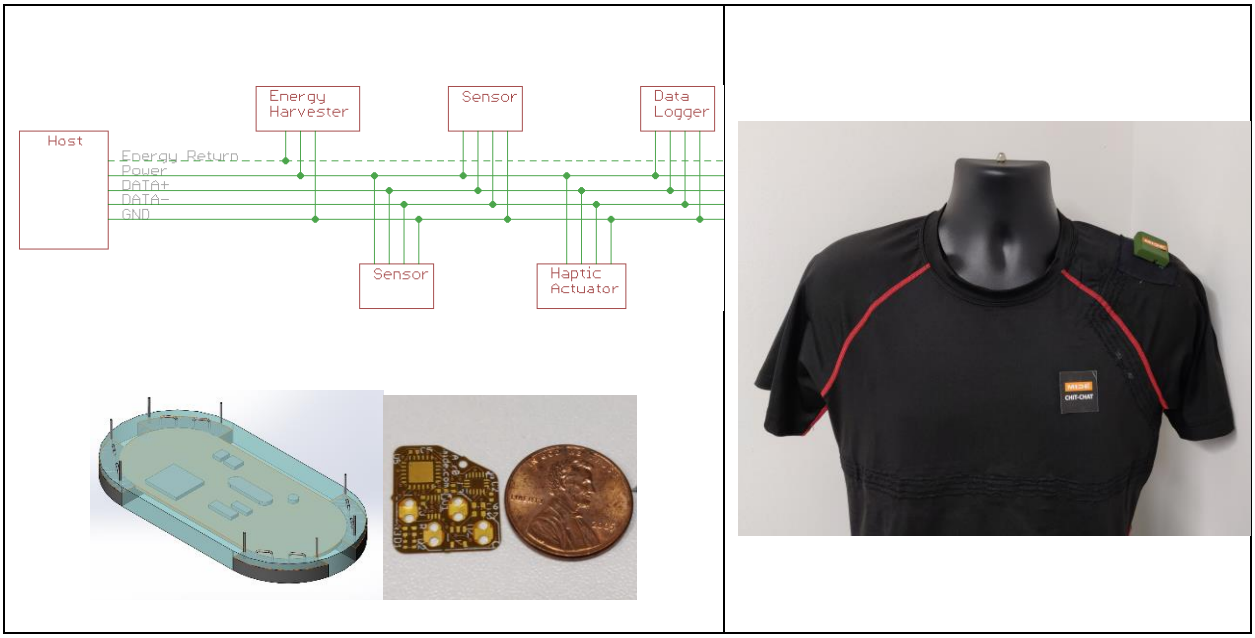

Figure 1: Garment-embedded sensor module concept with textile workflow-friendly interconnect mechanism to the e-textile. The example shown at left uses a conductive elastomer to isolate the flex circuit from possible fluid intrusion paths along a conductive stitch. A functional prototype using conductive thread, two inertial sensors and a snap-on Bluetooth battery/uplink module is shown at right.

CorBus consists of three major components: an innovative packaging and interconnect solution, an e-textile electrical interface, and a device-agnostic communications protocol (software) designed for body-area networks, which can be used together or separately.

The CorBus concept is built around interchangeable, plug-and-play sensor/actuator patches that connect to an integrated e-textile bus via an innovative 3D elastomeric packaging technique. Nodes interface to a shared 4-wire power and data bus integrated into the fabric. Using the device-agnostic communication bus, arbitrary assortments of sensors, actuators and other devices coexist, and sensor data is digitized right at the point of collection, maximizing data quality.

Packaging and Interconnect: While the long-term dream of e-textiles is to completely eliminate rigid and non-stretch components, conventionally manufactured ICs will be a part of the mix for some time to come. Mide's experience is that mainstream electronics technologies, including non-stretchable flex circuits and rigid chip packages, are imperceptible to the wearer provided they are sufficiently small and properly encapsulated. Mide's 3D encapsulation approach leverages existing, cost-effective electronics and textile industry infrastructure to bridge the gap.

Textile-embeddable smart patches are made using existing rigid, but miniscule, chip-scale and wafer-scale packages and circuit assemblies driven by the mobile phone and wearable markets. These are then packaged using controlled placement of conductive, insulative and special-purpose printable elastomers and flexible structural materials. This process ensures wearer comfort, makes a waterproof electrical interface between the electronics and a smart textile, and allows sensing elements to be printed right into the patch. These work with established textile industry practices and "cut-and-sew" workflows, enhancing low-volume manufacturing options.

E-textile bus and electrical interface: The CorBus e-textile electrical interface and bus topology is designed to provide moderate bandwidth (up to ~1Mbit/s) over a wide variety of available and emerging e-textile technologies such as conductive polymers, inks and threads, maximizing comfort and garment design flexibility with options for flame-resistant and wetsuit materials (e.g. neoprene). Existing e-textile conductors tend to have high and variable resistance, which changes as the wearer moves and gradually increases over the life of the garment. The simple data transmission scheme used in the CorBus electrical interface leverages peripherals commonly found on chip-scale microcontroller packages available today, requiring a minimum of external components. It accommodates both large resistances (K-ohms) and large time-varying resistance variations (10-fold differences between signal lines) on the e-textile, maximizing useful garment lifetime (wash and wear cycles) and providing early warning as the garment begins to wear out. So far, the technology has been successfully demonstrated on woven-wiring, metallized thread, and conductive ink-based e-textile systems, with the latter

demonstrated for survivability and flame-resistant (IFR) fabric blend adhesion via accelerated wash-cycle testing. As e-textile materials continue to improve, this robustness will translate to increased signal bandwidth and maximized useful life.

The low-voltage differential signaling data pair ensures reliability in harsh EMI environments and minimizes detectable RF emission.

Communication Protocol: CorBus includes a simple communications protocol stack optimized for the tiny microcontrollers that would typically be used as the bus interface. A key design feature is that the protocol adapts automatically to the available e-textile, providing graceful degradation (reducing bandwidth rather than loss of operation) as wear and damage occur.

Data-wise, each module presents one or more logical sensors or actuators with interpretation data such as names, unit labels, and optionally body site or location (coordinates). Using the shared bus, control, actuation and sensor measurements can by synchronized or scheduled around each other to avoid interference (for example, active electrodermal response measurements), and actions can be coordinated across body sites.

High Performance Haptics and Tactile Feedback (TRL7): Mide has developed SHIVR (Sophisticated Haptic Instruction via Vibrational Response), a smart, distributed haptics and tactile feedback system (US patent 9,836,123 B2) using the CorBus body-area networking protocol. This system uses piezoelectric actuators to provide crisp, high-authority tactile cues, and scales from simple single-point messaging to research-quality garments with hundreds of actuators (a 52-actuator vest for cueing of helicopter pilots in degraded visual environments is shown in Figure 2). Each tactor includes its own waveform generation and actuator drive circuitry, able to vary waveform, frequency, and amplitude per-tactor in realtime. Using the CorBus network, an arbitrary number of tactors can be connected to the shared bus without per-tactor wiring, complex haptic messages can be coordinated across many body sites, and actuator drive voltages (~100V) are safely contained in each tactor and do not cross the body. By combining CorBus sensing and actuation, realtime sense-and-respond tasks such as proximity alerting for situational awareness can be implemented.

Figure 2: Two actuator packaging variants of Mide's SHIVR smart haptics system (left) and completed evaluation system (right). Note that the initial effort focused on maximum performance; flexible actuators were not a project requirement.

About Us

Mide Technology is a research and development company that excels in providing innovative engineering services leading to value-added products and solutions for our customers. To ensure an effective solution for our customers, Mide approaches every problem with a focus on requirements and systems engineering. Our engineers understand how each component affects, and is affected by, the rest of the components in the entire system. We work with our customers as team members so we are able to better understand how our product fits into their system and solves our customers' problems.

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