Miniature, High-Speed, Data Acquisition Systems

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History of Miniature Data Acquisition Systems (MDAS)

- Miniaturization of electronics through the last several decades made possible by:
  - Vacuum tubes replaced by transistors
  - Transistors grouped together into integrated circuits
  - Specialized integrated circuits developed, multi-chip module (MCM)
  - Development of large non-volatile memories
  - Improvement of battery energy density
    - Carbon-zinc 130,000 J/kg (not rechargeable)
    - Lithium-ion 460,000 J/kg (rechargeable)

Specialized Data Acquisition

- Conventional data acquisition systems are not applicable or practical for specialized testing scenarios
  - Where interconnecting wires are not possible or practical
  - Large size limits ability to operate in severe shock environments
  - Small size is required to fit into many modern test scenarios such as
    - Anthropomorphic systems
    - Other human injury studies

MDAS Design Criteria

- Stand-alone operation
  - Computer not connected during data acquisition
- High sampling rates
  - 1 microsecond between samples (adequate for air blast data acquisition)
- Small size
- Non-volatile memory
- Built-in signal conditioning
  - Piezoelectric
  - Piezoresistive
  - Voltage inputs
- High capacity battery
  - Operate all day without recharging

ARA Experience in Data Acquisition Systems

- Extensive field testing
  - Understand requirements of general and specialized test protocols
- Integration of many complex instrumentations systems
  - Large rack-mount system capabilities into much smaller miniaturized packages (have developed generations of data acquisition systems)
- Miniature data acquisition systems
  - Have designed and constructed several generations
  - Deployed these systems in numerous field experiments
  - Improved systems as needed to meet changing acquisition requirements

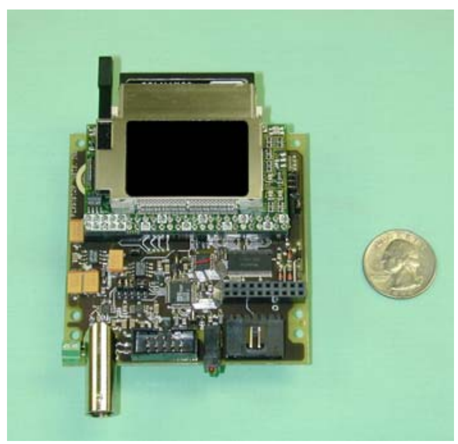
ARA Experience in Data Acquisition Systems

- Examples of ARA data acquisition systems over time

Late '80s

Mid '90s

Late '90s



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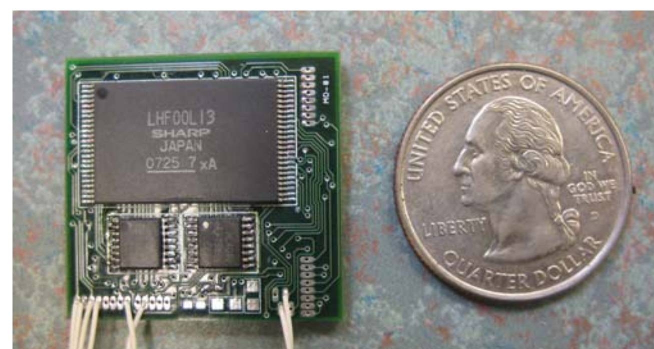

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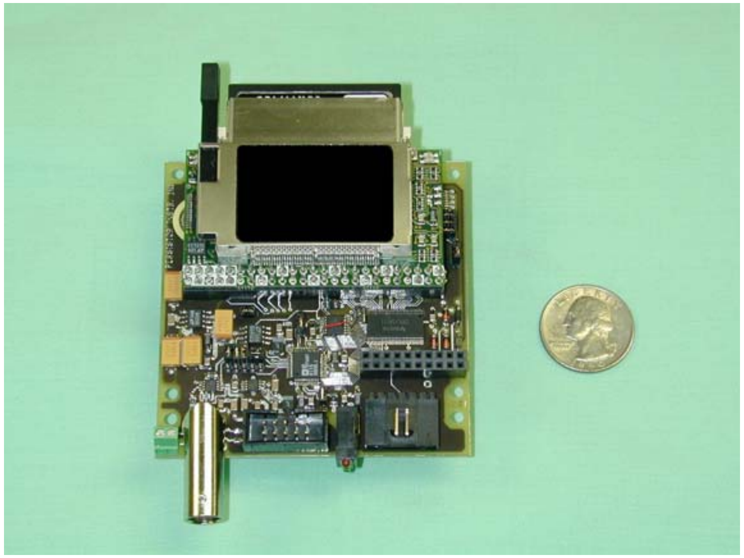
MINIDAS Attributes

- Small-stand alone package
  - Electronics are approximately 3”x4”x1” w/o battery
- Adjustable sample rates
  - Maximum of 1 megasample per second
- High resolution 16-bit digitizer
- Rechargeable 29-hour lithium polymer battery (1” high)
- Utilizes 128-megabyte nonvolatile compact flash memory (removable)
- Built-in signal conditioning for added versatility
- Proven to withstand high accelerations
  - Hundreds of g’s from explosive tests
- High data fidelity due to high bandwidth (no cable losses) and less noise for better S/N ratio

MINIDAS Package



- Green indicator = ready to record
- Red indicator = trigger received
- Yellow indicator = battery low

Application Example #1

- Three MINIDAS units placed in chest cavity of dummy during explosive test (where dummy gets thrown by high overpressures)
- Triaxial accelerometer
  - Early-time acceleration and velocity
  - Impact deceleration
- Long time between the test event and recovery of MINIDAS system due to safety protocols

Application Example #2

- Four MINIDAS units placed in the vest of 17 soldiers during training exercises (explosive breaching events)
- Pressures on the helmet and the vest shoulders measured

Application Example #3

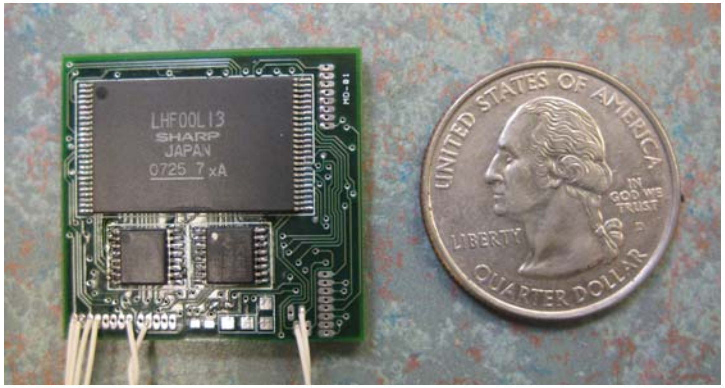
- Pressures measured on ARA “Ironman” test dummy during a simulation of a suicide bomber explosion on a bus
- Pressures were measured on the chest and sides of the anthropomorphic dummy

MICRODAS Prototype Development

- Although the MINIDAS is small, there is still a need for even smaller packaging
- Microdas units are being developed with many of the same features, but in a much smaller package to allow:
  - More cost effective deployments
  - Easier to harden
  - Overall system cost lower allowing more acquisition channels per test

MICRODAS Attributes

- Small-stand alone package
  - Electronics package is approximately 1”x1”x0.25” w/o battery
    - Custom battery 1” x 0.25”
  - Package sampling rate, signal conditioning and filtering customized during fabrication



- 1-microsecond sampling interval (max rate)
- High-resolution 16-bit digitizer
- 4-megabyte nonvolatile memory
- Built-in signal conditioning
- Higher resistance to shock
  - Expect 100,000 g w/appropriate packaging
- Lower cost than MINIDAS

Lower Fielding Cost for MINIDAS and MICRODAS

- Greatly reduced or eliminates test site transducer cables to an instrumentation van
  - Cost of cable, trenching, and junction boxes
  - Labor costs
- Use of instrumentation van eliminated and attendant
  - Cost of van
  - Cost of heating/cooling
    - Generator or commercial power
  - Cost of protection
    - Blast/fragmentation
    - Lightning

Remote Acquisition Issues for MDAS Units

- Trigger signal – how to ensure consistent data acquisition
  - Radio-based trigger capability already developed
- Data download approach
  - Download memory cards – have been doing
  - Wireless technology – Wi-Fi
- Battery recharge technique
  - Ultra-low current standby mode desirable
  - Minimizes recharging of batteries

System Cost

- MINIDAS
  - Approximately $2000 per channel in volume
- MICRODAS
  - Projected to be $500 per channel in volume

Beyond MICRODAS

- Specifications similar to MICRODAS
- Combine most components onto single integrated circuit
- Projected size 0.2”x0.2”x0.1” w/o battery

Summary

- Current MDAS technology allows sophisticated measurements to be made cost effectively in remote and harsh environments
- Cost effectiveness allows more data to be taken for a given test scenario
  - Elimination of cabling, trenching, junction boxes
  - Reduction of labor costs
  - Lower operational costs (van, protection, etc.)
- Higher data fidelity
  - Bandwidth higher
  - Better S/N ratio
- Increased hardening capability due to size
- Future designs will offer
  - Even smaller designs
  - Lower costs