

# Magnetic Field Mapping for Characterizing Energized Electrical Circuits

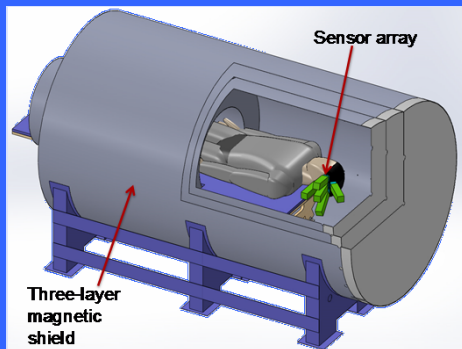
Detect the state of an electronic device and localize the position of electrical components within circuit

## Background/State of the Art Approach, Metrics and Outcomes

- State detection of an electronic device is measured with a low-sensitivity magnetic sensor at frequencies in the 10s to 100s of kHz range.
- Low frequency signatures (1 Hz to 1 kHz) have not been widely researched.
- Low frequency magnetic fields are not shielded by conductive materials.
- DTRA and NNSA have studied signatures for state detection of devices of interest.

## Innovation

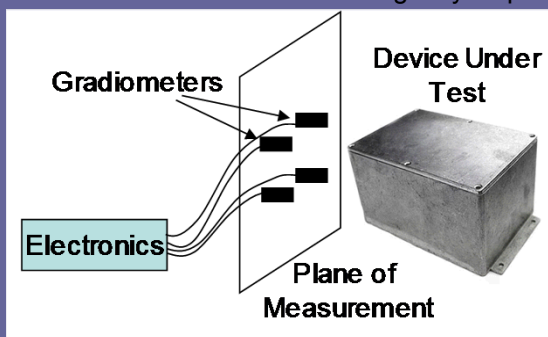
- We have developed an array of atomic magnetometers AMs for magneto-encephalography (measurement of the magnetic field of the brain).
- Repurpose system to measure devices of interest
- Study signature from 1 Hz to 1 kHz and localize sources
- Demonstrate high sensitivity operation outside of a magnetic shield



Defense Nuclear Nonproliferation R&D

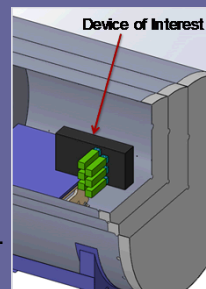
## MAIN ACHIEVEMENT

- Long-term goal: Develop an array of high-sensitivity magnetometers that can operate outside the lab to map the magnetic field of an electronic circuit and localize critical elements in conjunction with x-ray imaging.
- Provide actionable information to emergency responders.



## HOW IT WORKS

- Our (AMs) have sensitivities of 10-20 fT/rt-Hz from 1 to 200 Hz.
- Make a planar array and raster the device across the array.
- Source localization algorithms invert field maps to current positions and distributions.
- Demonstrate unshielded operation of AMs by using cancellation coils and gradiometry.



## ASSUMPTIONS AND LIMITATIONS

- High sensitivity magnetometry is unproven in unshielded environments.
- Ferromagnetic enclosures can shield low-frequency fields.
- In a shielded environment, the device of interest could saturate the AMs

## Impact

- A new capability for state detection of electronic devices.
- Provide actionable information to emergency responders.
- Allow more informed decisions in high-consequence situations.

TRL start: 3

TRL finish: 5

## Goals/Action Plan

Measure electronic devices of interest with our shielded atomic magnetometer array: (Years 1 and 2)

- Adapt our system to accommodate shoebox-sized test devices.
- Develop magnetic source localization algorithms.
- Measure devices of interest

Demonstrate measurements outside of a shielded environment: (Years 2 and 3)

- Purchase eight newly developed high-sensitivity commercial AMs.
- Employ gradient measurements of the magnetic field and field cancellation coils.
- Demonstrate the mapping of the magnetic field of a device of interest.

## Team

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