INTRAWEAPON WIRELESS COMMUNICATION

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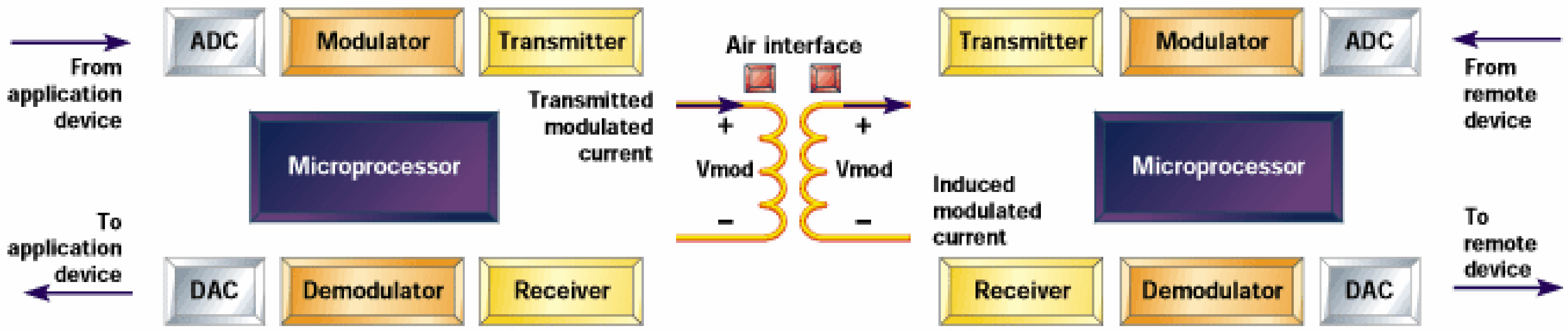
Outline

- System
- Spin Dependent Tunneling (SDT) or Magnetic Tunnel Junction (MTJ) Sensor Technology
- Applications of SDT Sensors To Intraweapon Communication
- Fuzing and Surveillance.

Intraweapon Wireless Communication System



The magnetic induction system communicates by setting up a quasi-static field around the transmitting coil. Current Commercial applications include wireless headsets, MP3 players and medical devices.

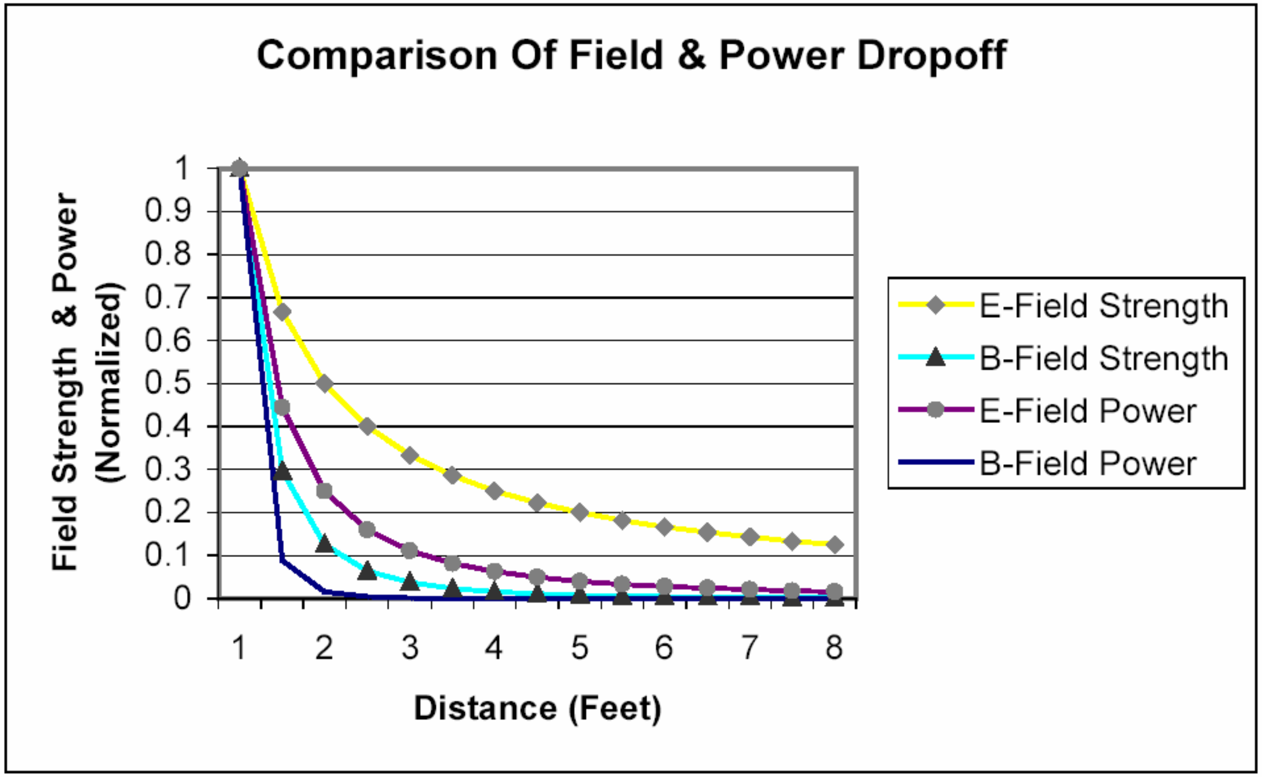
Magnetic Communication

- Unlike RF communication that propagates an E-field plane wave in free space.
- Magnetic system sets up a quasi-static magnetic field around transmitting coil
- Second coil intersects the time varying magnetic flux density (B-field).
- Modulated voltage is processed and data recovered.
- RF uses E-field, Magnetic uses B-field.

Magnetic Induction vs. RF Wireless Characteristics

- Wireless propagates RF plane wave
  - Flow of energy from transmitter to receiver
  - RF is not contained -- **security** risk
- Magnetic induction remains localized
  - Little flow of energy
- Magnetic induction system very localized
  - Magnetic fields decrease as inverse cube of distance

Magnetic Induction vs. RF Wireless



The magnetic field (B-field) component drops off at a $1/R^3$ compared to an RF plane wave that drops off at 1/R.

Energy $E \sim B^2$
$E \sim 1/R^6$

Magnetic Induction Communication Considerations

- Survivability After Weapon Penetration
- Sizing and Hardening of Transmitter Unit
- Required Receiver Sensor (SDT) Sensitivity
- System Power
- Size
- Cost

Magnetic Field Transmitter Considerations

- *The bomb casing will act as a shield to the incoming magnetic vehicle signatures but absorb internal signal.*
- *Communication effectiveness is composed of 3 complicating factors: absorption losses (flux shunting), reflection losses, and secondary reflection losses.*
- *The complex calculations are a function of structure geometry, permeability, conductivity, and frequency, all interactively nonlinear.*
- *The major factor for our application is reducing absorption losses.*

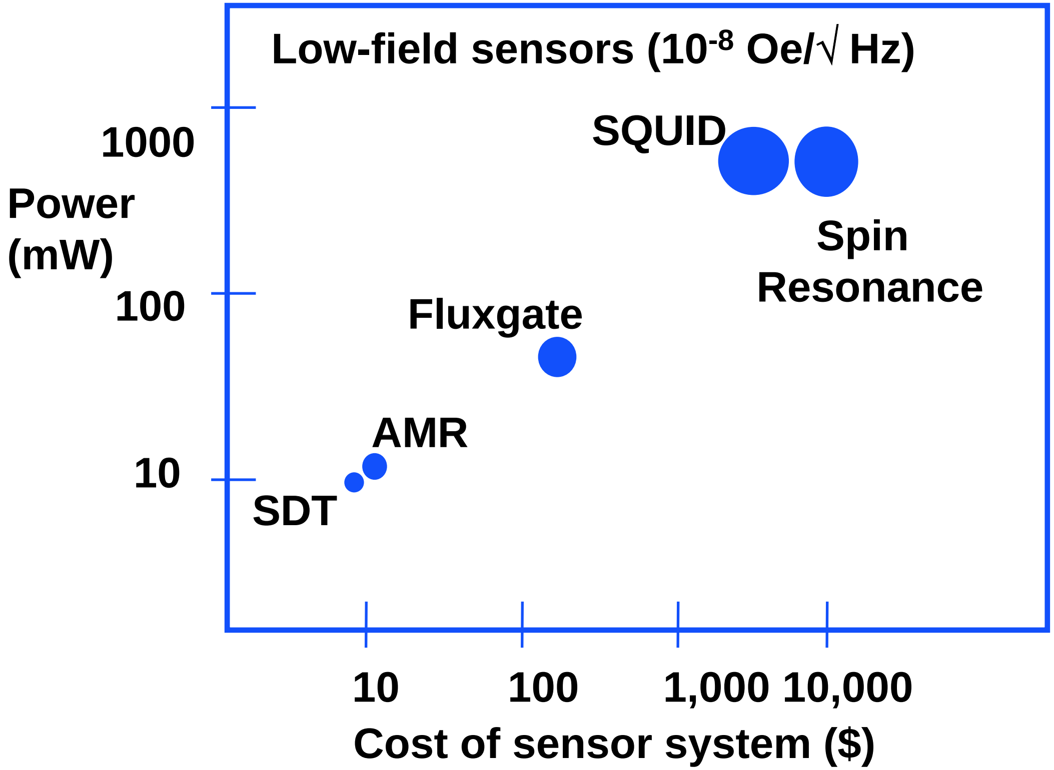
Magnetic Field Detector Considerations

- Pickup coil responds to dB/dt
  - Voltage output is proportional to frequency
  - Large coils and many turns required at low frequencies
- Magnetic field detectors (SDT Sensors) respond to B Fields
  - Voltage output frequency independent
  - Very small, very light solid-state sensors

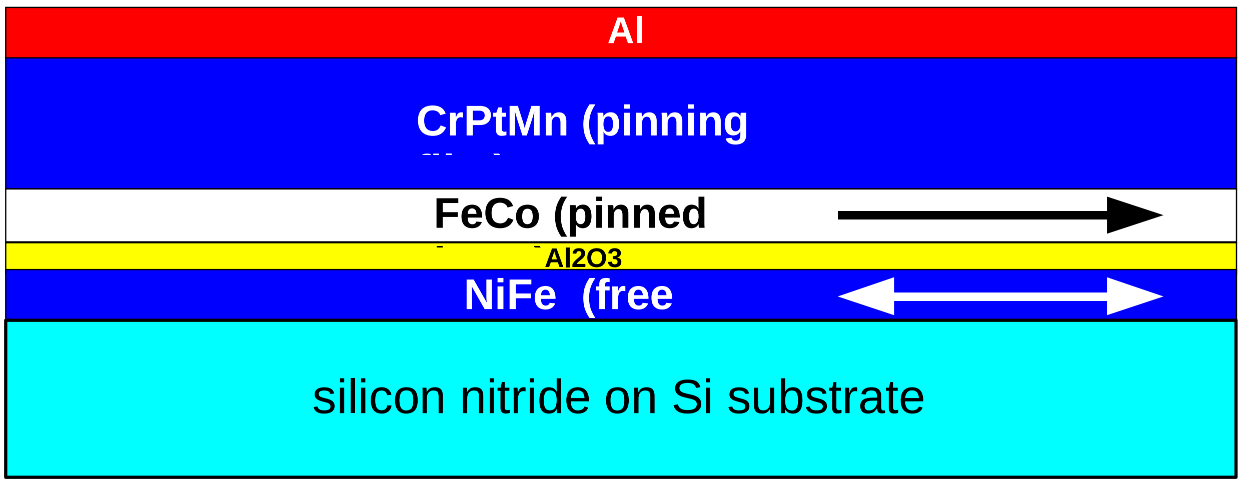
SDT Magnetic Receivers

- *Quantum tunneling of electrons through a thin insulator between two magnetic layers*
- *Tunneling current is effected by the relative orientation of magnetic moment in layers*
- *One magnetic layer pinned and one layer free to respond to external fields*
- *All current passes through the interface-high Tunneling Magneto Resistance (TMR) (high sensitivity)*
- *Extremely high resistance per unit area (low power)*

Very Low Field Magnetic Sensing/Receiver



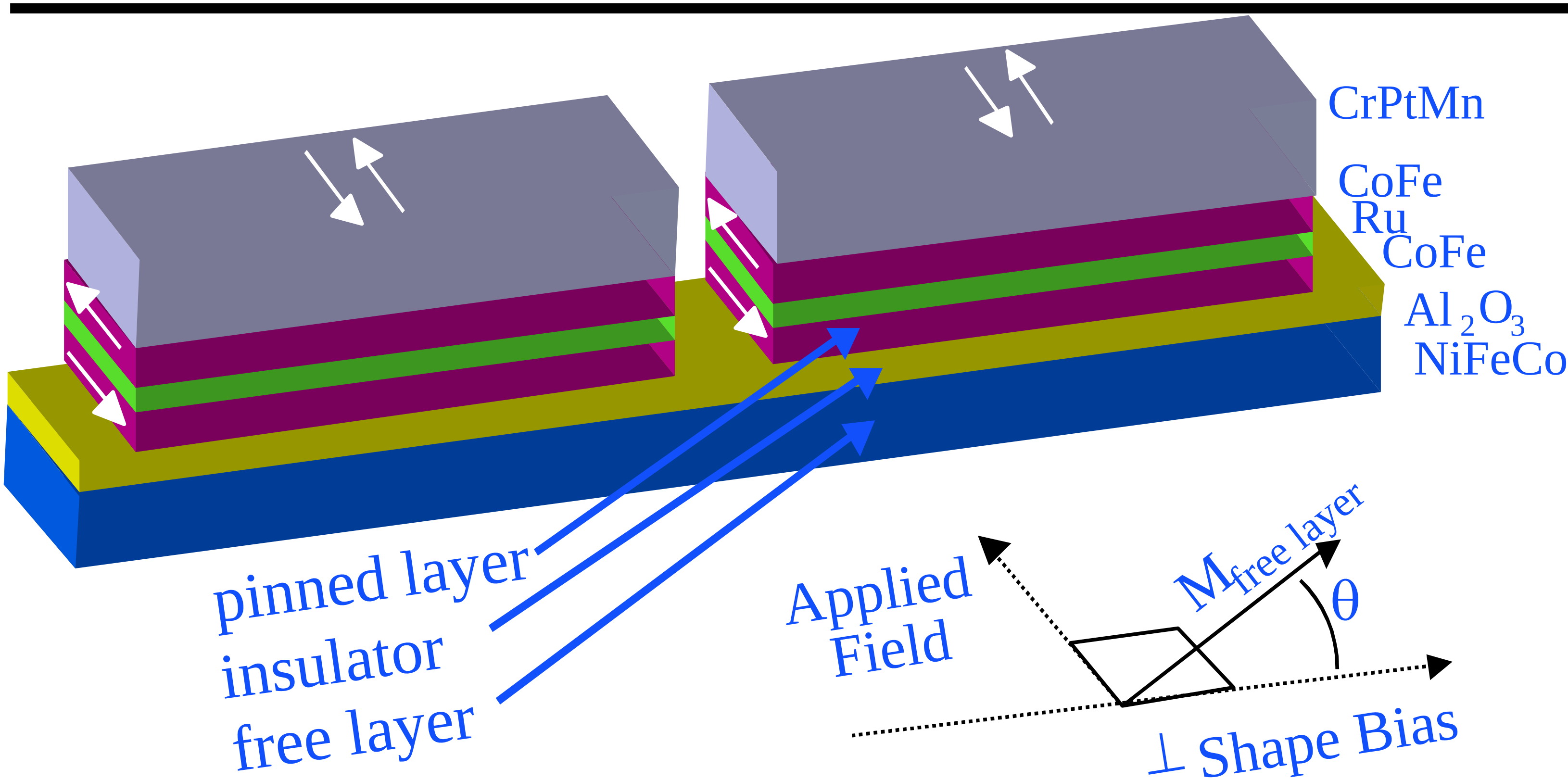
SDT Layer Structure



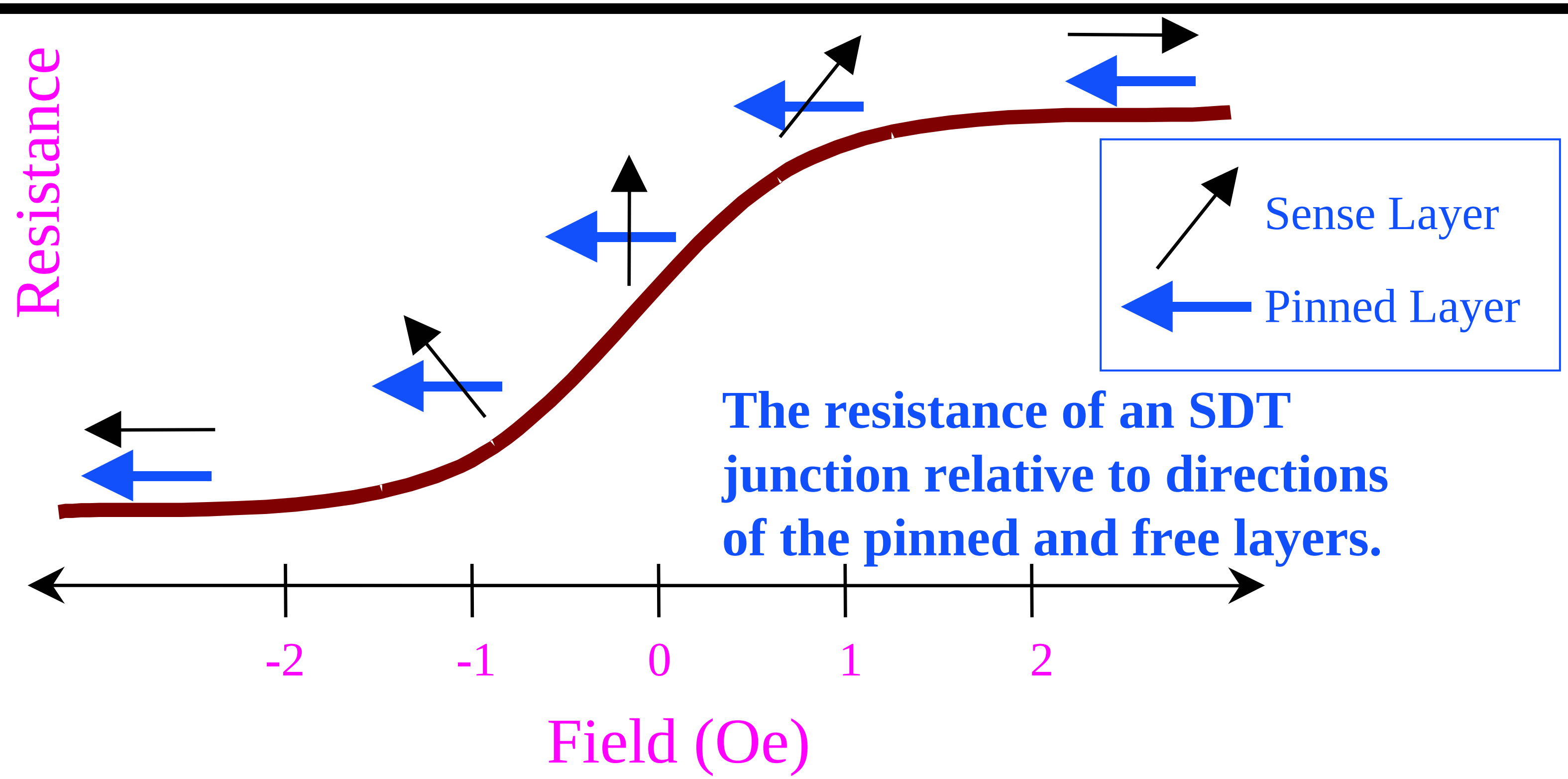
Sensing direction and easy axis of the free layer.

The resistance of the sensor is measured by feeding a current vertically through the stack including through or "tunneling" through the insulating layer.

Individual SDT Sensor



Current SDT Sensor Response



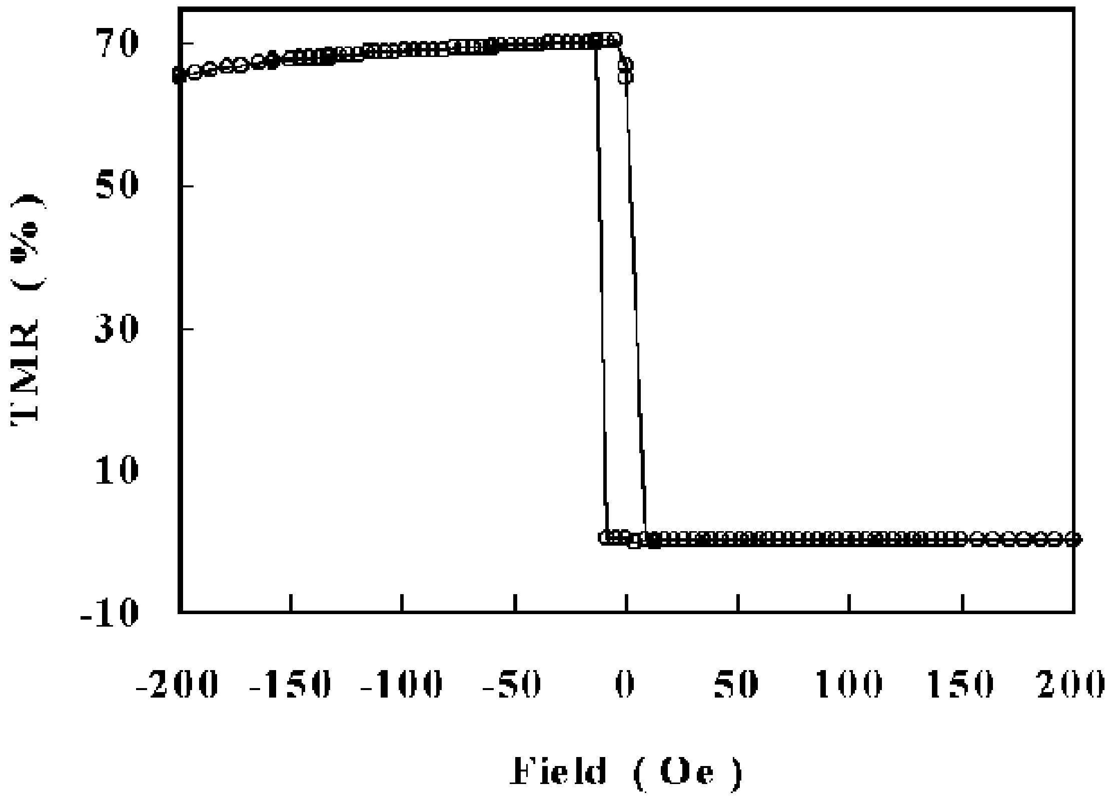
The resistance of an SDT junction relative to directions of the pinned and free layers.

Low Power SDT Sensor

Operational Tradeoffs

- *Resolution of the SDT sensor is determined by the amount of system power available*
- *The higher the required resolution, the higher the power required.*
- *The two variables that can be manipulated are sensor resistance and amplifier supply*
- *SDT sensors can be manufactured from tens of Ωs to 100s of KΩs.*
- *Sensitivity is a tradeoff to power consumption*

Record 70% TMR Reported



% TMR indicates the % change in resistance with a given applied field.

This TMR was recently reported in a recent research project.

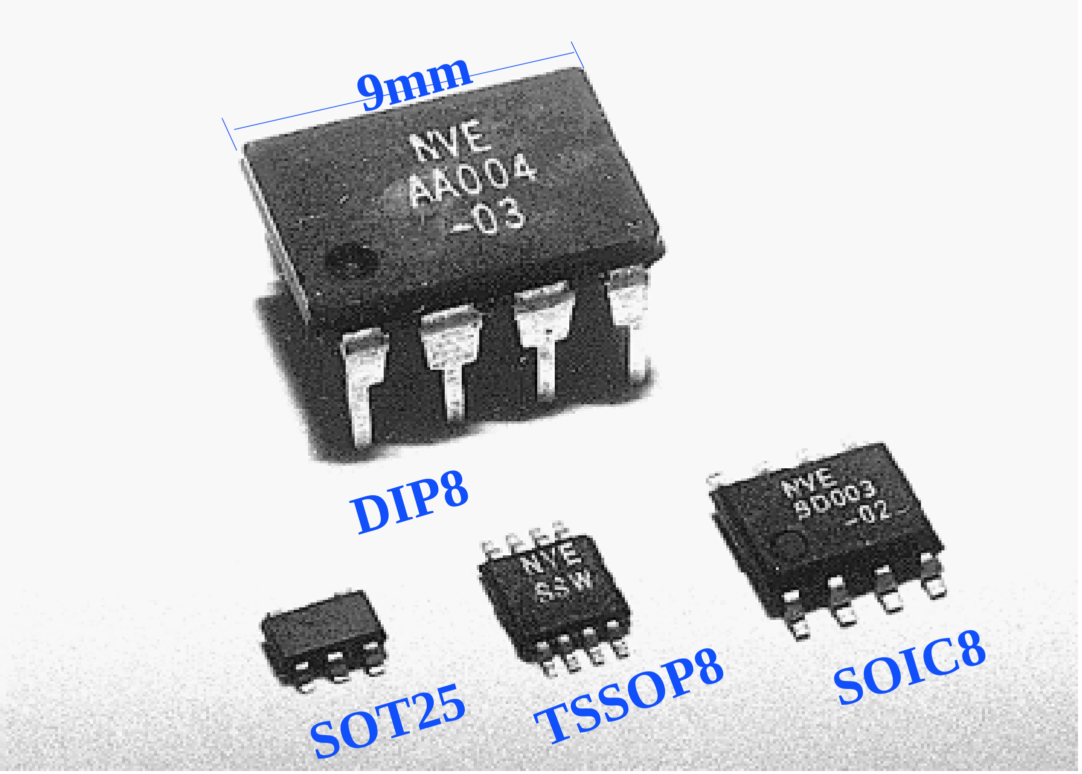
Applications of SDT Sensors To Intraweapon Communication

- SDT sensors packaged in SOIC packages
  - Small
  - Lightweight
  - No connections to external antenna necessary
- Output 100 mV/Oe with 5 V supply
  - Frequency independent output voltage
  - Extracts no power from signal

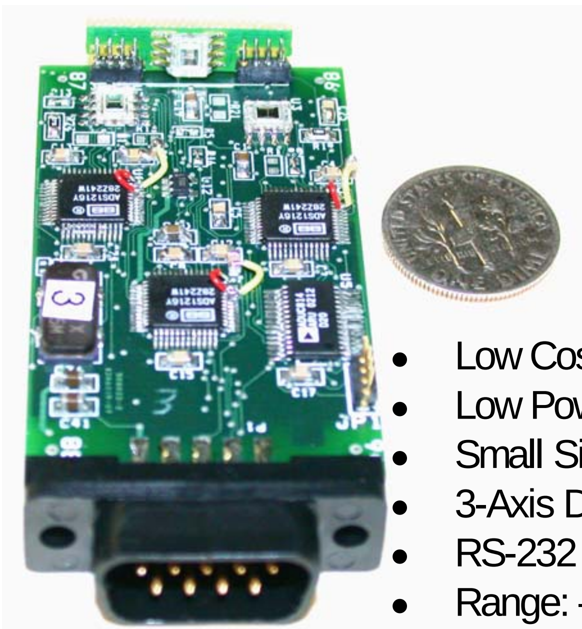
Conclusions

- *SDT sensors will develop sensitive, power and cost effective sensing for intraweapon communication as well as fuzing and surveillance systems*
- *Magnetometer applications*
  - *Unattended Networks*
  - *Security*
  - *UXO*
  - *Traffic Management*

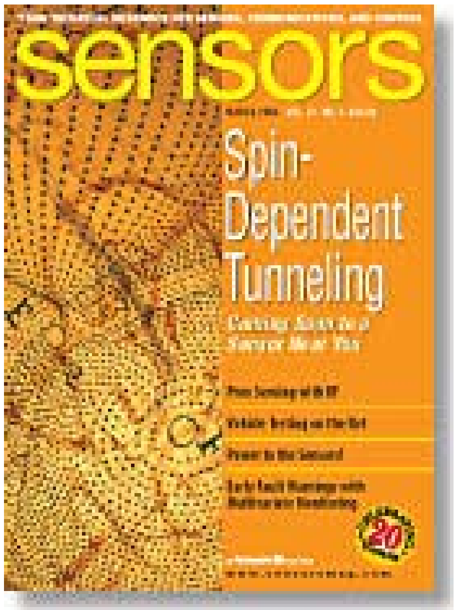
NVE Sensor Packages



3-Axis Smart Digital Magnetometer Using SDT



- Low Cost
- Low Power
- Small Size
- 3-Axis Digital Resolution
- RS-232 Interface: 9600/19200 Baud or RS-485
- Range: –1 to +2Oe, 1µOe Resolution
- Signal bandwidth: 154Hz
- Available in a Port-Powered Version



Acknowledgments

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