HA Consulting

Development of a Shock Gage and Self Acting Fuze for Weapons and Safety Systems Activation

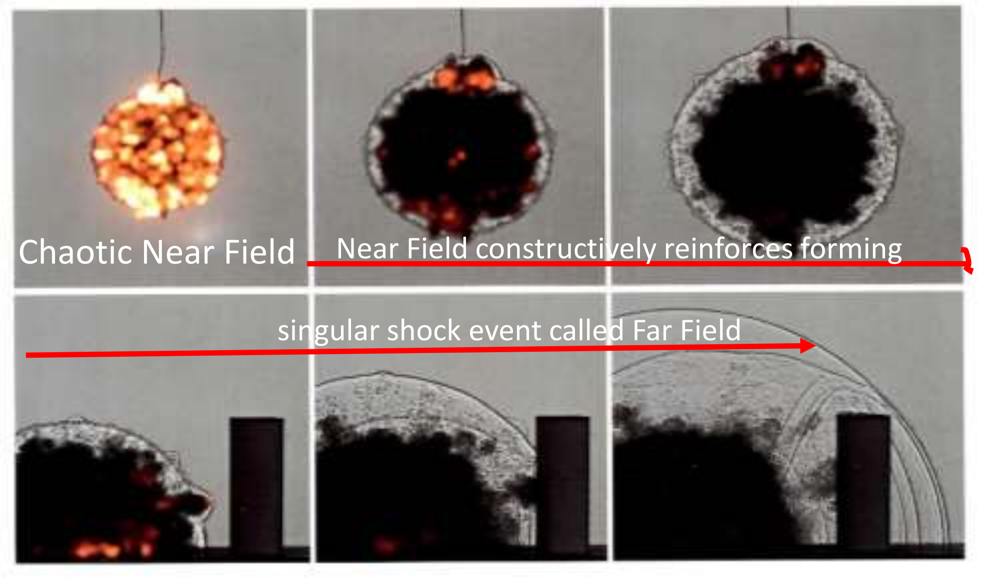
Program Overview

OBJECTIVE:

- DEVELOP AN ULTRA LOW COST SHOCK GAGE TO MEASURE DYNAMIC PRESSURE, IMPULSE, MEDIA DENSITY AND CONDUCTIVITY
- DEVELOP A SELF POWERED FUZE TO ACTIVATE DETONATORS AND SQUIBS UPON RECEIPT OF SHOCK WAVE FROM AN EXPLOSIVE EVENT

Definitions:

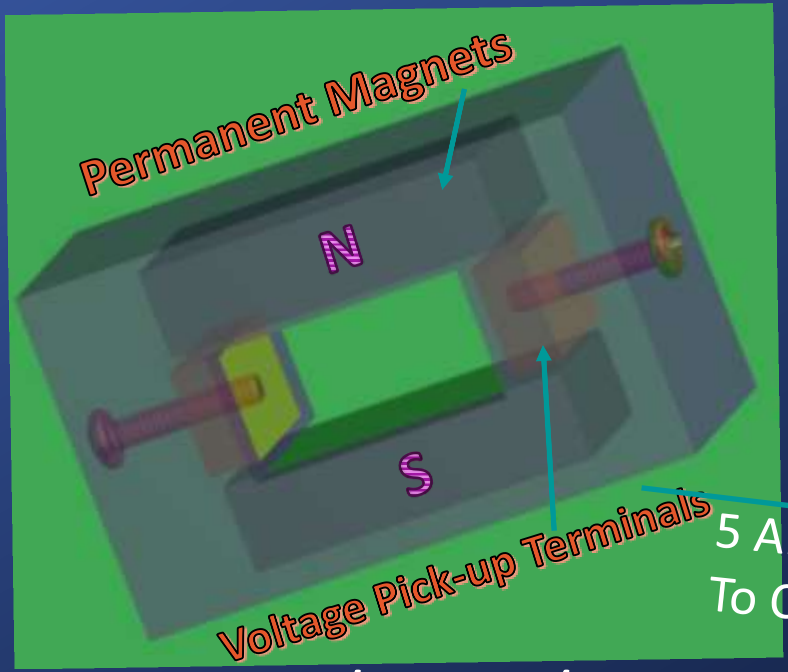
- Shock: A very rapid spatial change (jump) in environmental conditions of pressure, temperature, and density; similar to the sense of an approaching storm front but on the Quantum Scale.



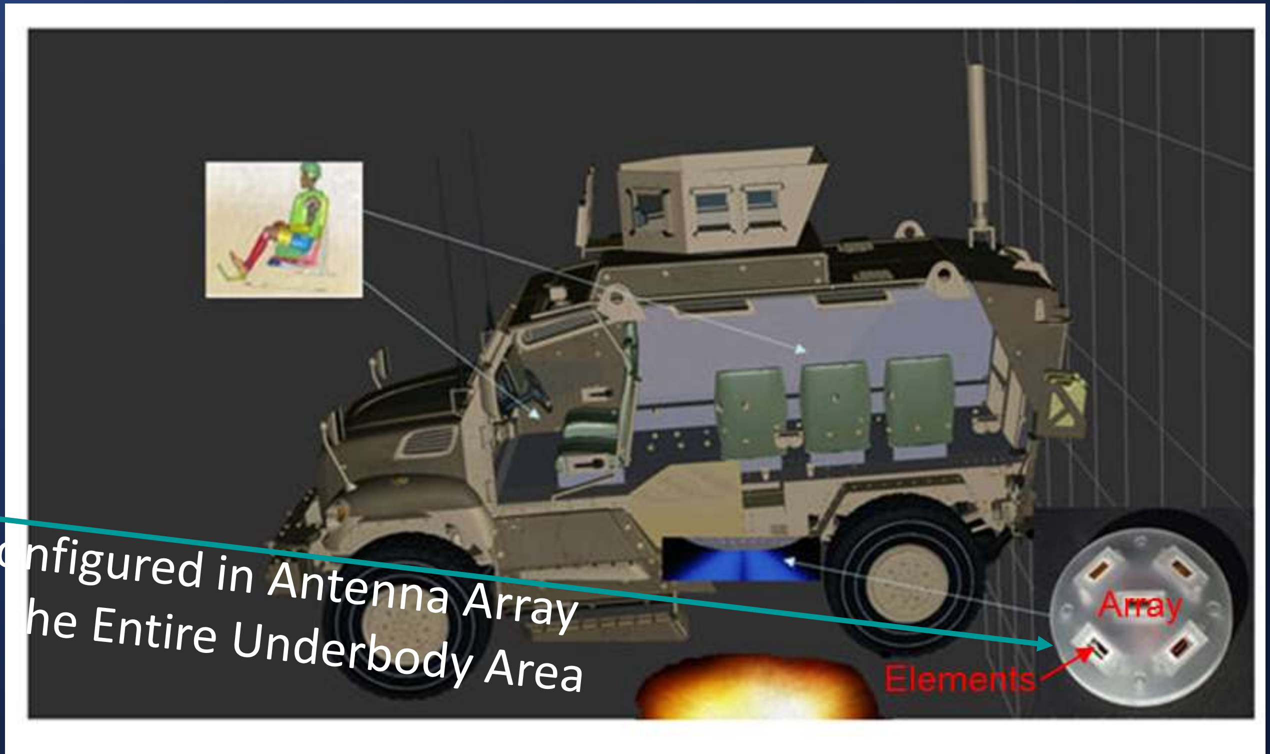
- Treacle: The ionized mass a shock wave drags behind it. From the British word for Molasses.
- B-Field: Invisible lines of magnetic flux and similar to guitar strings, which when plucked by a Treacle mass, vibrate and separate charge
- MACH: Speed (velocity) of a Shock Wave in unitless units expressed as a ratio to the speed of sound of the surrounding environment.
- Alfvén Wave: The B-Field vibration generated on the Treacle Mass that moves electrical charge.

Example Application of Shock Sensor/Fuze

- HA Consulting’s AIO (All in One) Sensor/Fuze Unit to protect military vehicle occupants from buried IEDs.
- A Magnetogasdynamics (MGD) Constant Area Generator Device senses shock and utilizes energy contained in the shock to fire squibs or detonators and deploy air bags, seat strokers or countermeasures such as back blasts in less than 200 microseconds.

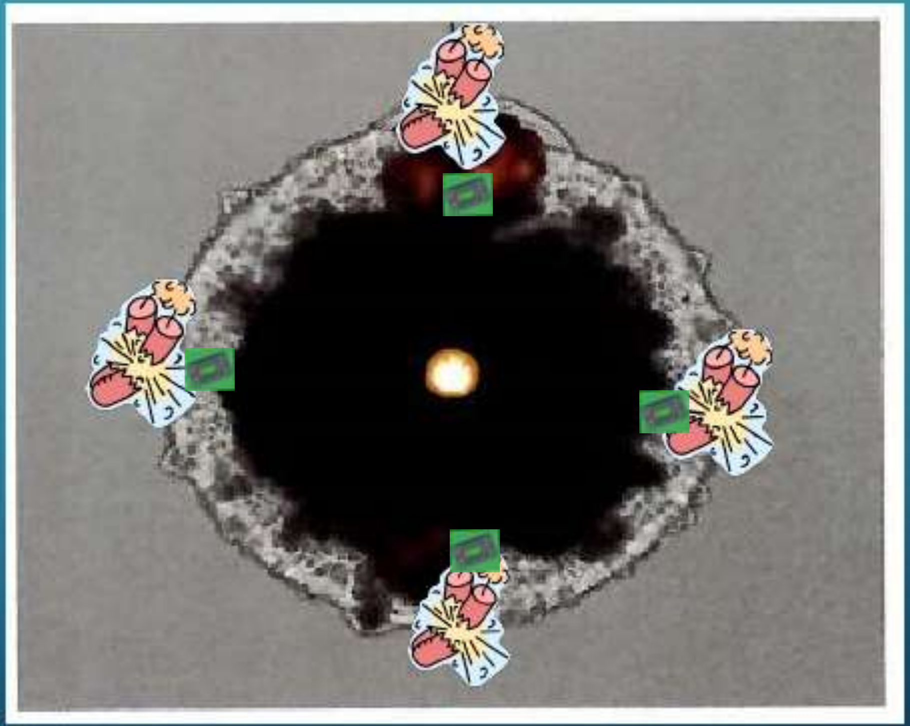


3/8” X 3/4“
AIO



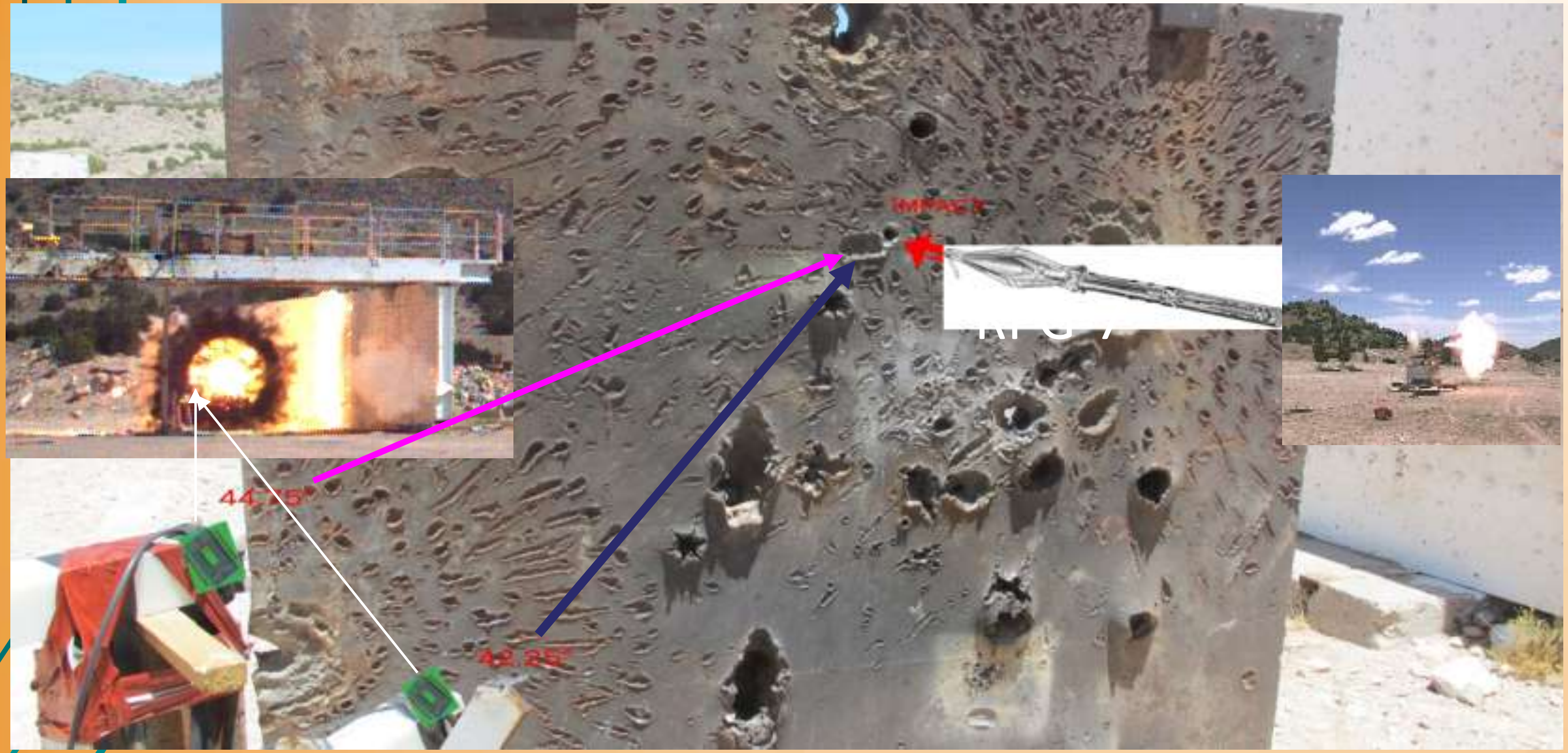
Example Application of Shock Sensor/Fuze

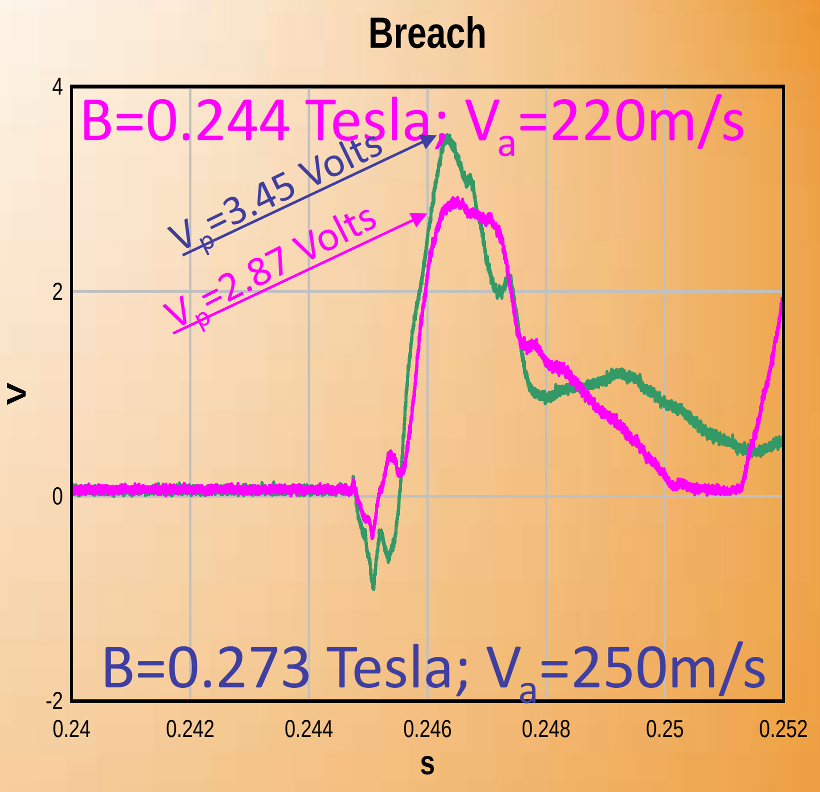
An example sensor/fuze application of special interest is sympathetic simultaneity of munition arrays providing a force multiplier via energy focusing. This game changer will revolutionize explosive weapon deployment.



Circular Array Detonated Synchronously with Center Charge Shock Wave Power

Measurements Inside Fireball

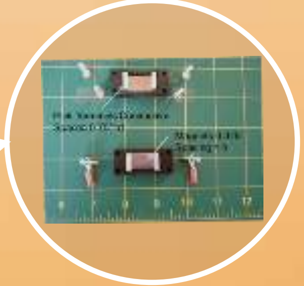




Vpa = 663; Vs=913
P = (663)(913)(1)(0.00014503) = 88 psi
Vpa Vs ρ_o

Vpa = 617; Vs=837
P = (617)(837)(1)(0.00014503) = 75 psi
Vpa Vs ρ_o

RPG

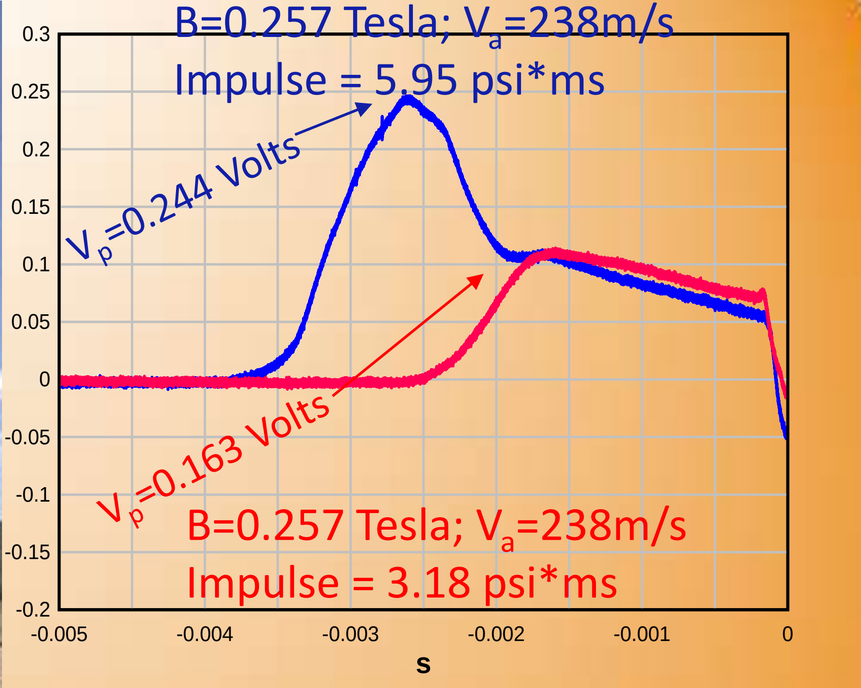


Pulse Train: Sensor measures first pulse were the atmospheric conditions in front of pulse are known.

Vs (Shock Vel.) = V_a (Alfvén Vel.) + Vpa (Particle Vel.)
V_a = Predetermined Constant related to B Field
= Alfven Wave Velocity

ρ_o = Air Density in front of 1st Received Pulse
Vs = V_p (peak voltage)/ ((B)(d))
P = Dynamic Pressure

Tests 1 and 2 Determination of Physiological Response



Measurements indicate 1% Probability of Level 2 Ear Damage

Vpa = 663; Vs=913

P = (51)(289)(1)(0.00014503) = 2.14 psi

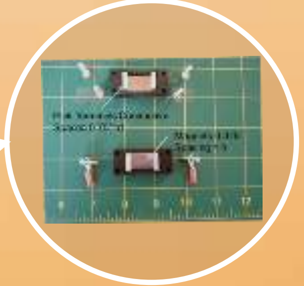
Vpa Vs ρ_o

Vpa = 617; Vs=837

P = (34)(272)(1)(0.00014503) = 1.35 psi

Vpa Vs ρ_o

RPG Launcher



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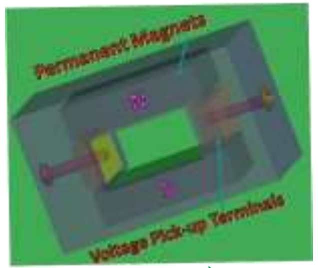
Vs = V_p (peak voltage)/ ((B)(d))

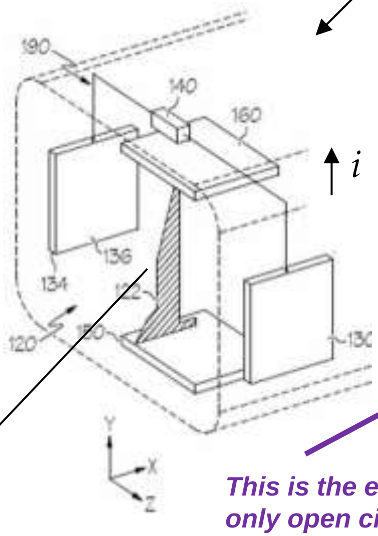
P = Dynamic Pressure

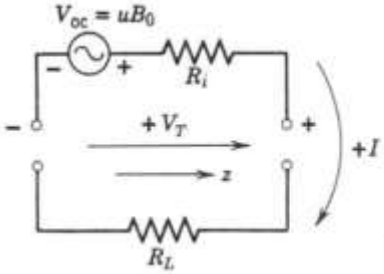
Velocity, Conductivity, Pressure & Analog Computer System Solution & Sensor

Compact Hardened Shock Wave Powered Sensor Output Yields Velocity. Pressure, Impulse, and Conductivity of a Shock Wave

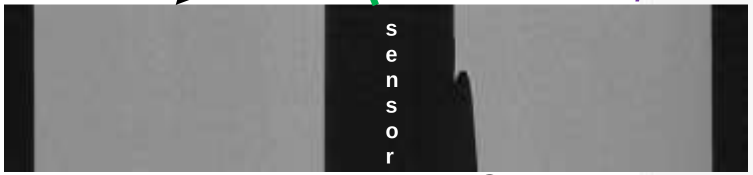
120 – One in³ Sensor
122 - Shock Wave
130 – Positive Electrode
136 - Negative Electrode
140 - Voltage Recorder
150 - Permanent Magnetic Pole
160 - Permanent Magnetic Pole
190 - Voltage (V_t)/Current (i) Output



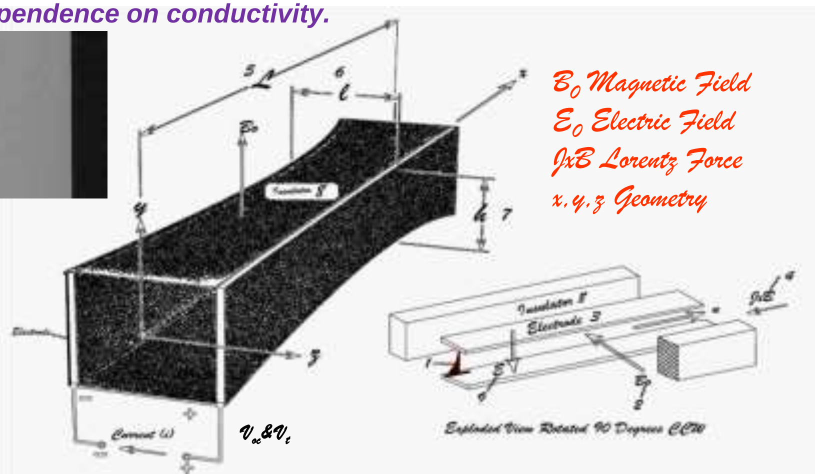




This is the equivalent electrical circuit. For the sensor we measure only open circuit voltage. We extract the Alfvén *wave from the signal which is current flow (Northern Lights). This defines the forcing term and our system of equations on the right are closed. Note there is no dependence on conductivity.*

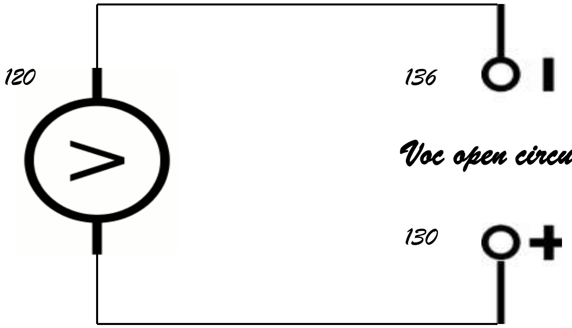


1. *Shock Wave @ velocity u_0*
2. *Electric Field*
3. *Electrodes*
4. *Lorentz Force*
5. *Channel Length*
7. *Channel Height*
8. *Insulators and Magnetic poles*



Sensor

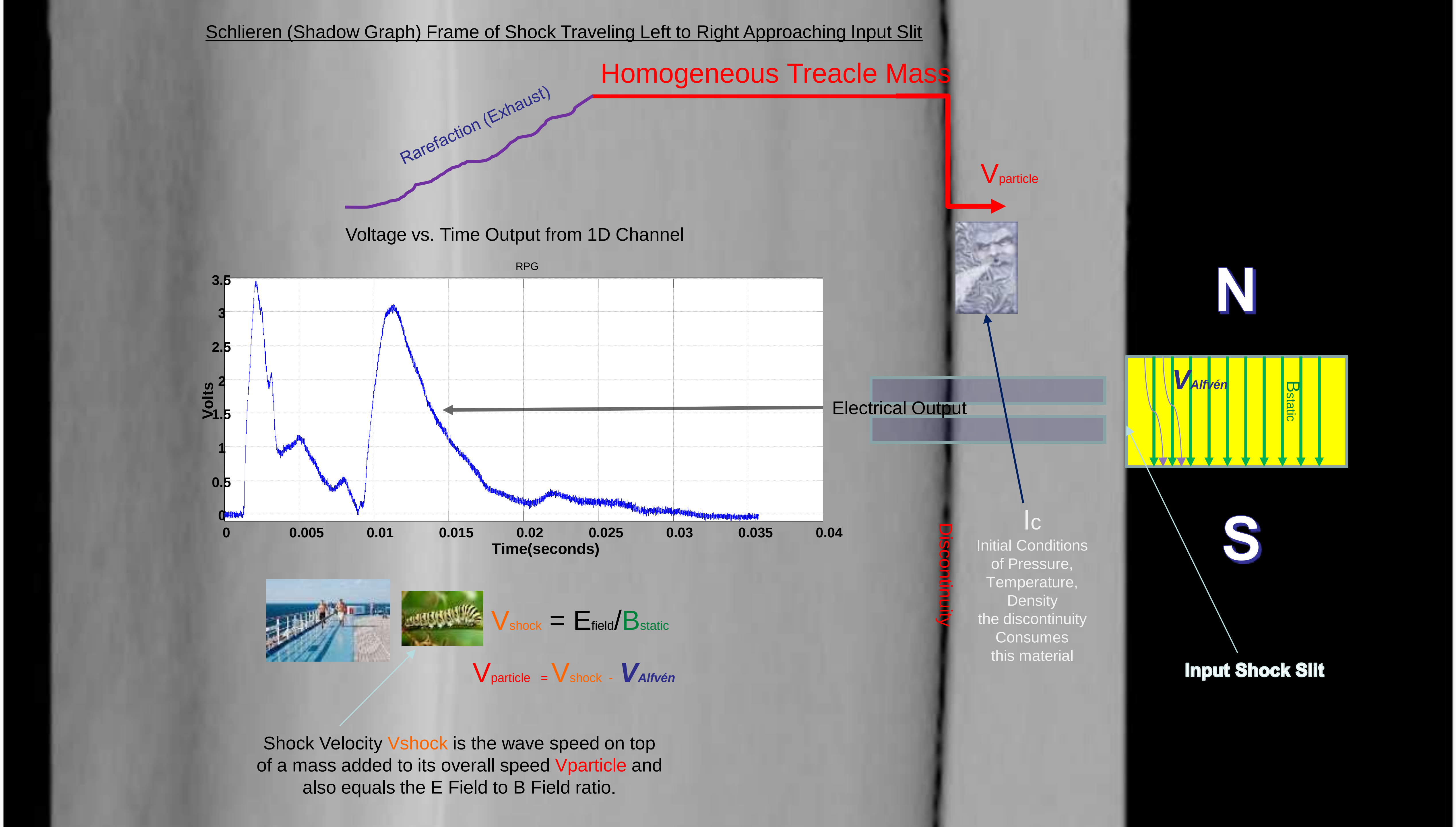
Set-up &Measurement of U (shock velocity m/sec) and P (psi)



Voc Measurement

Measurement Algorithm:

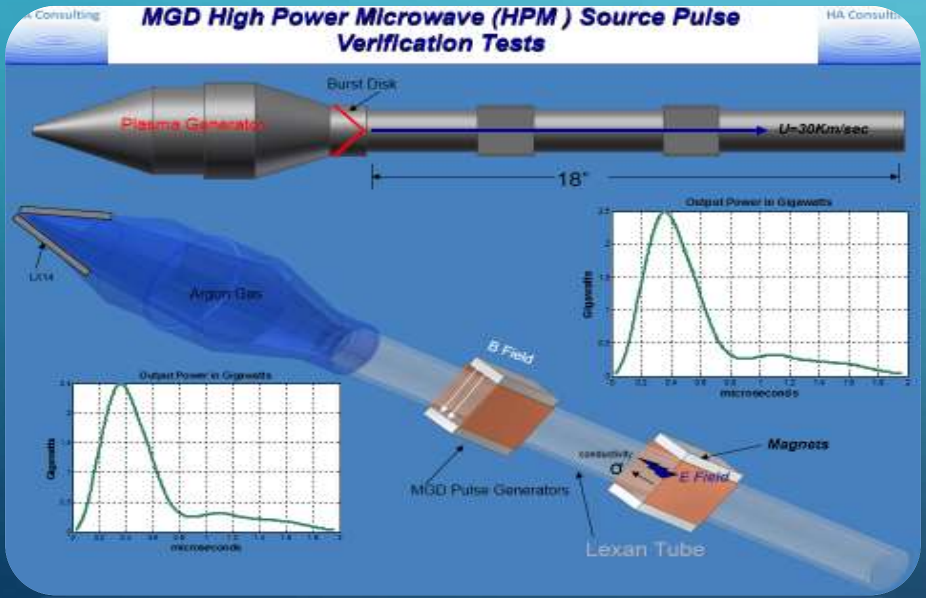
1. Sensor designed as Engineering Dirac Delta sifter. It picks U (Entry Shock Velocity) and P (Entry Pressure) off the leading edge of mass slug of the Shock Wave at channel entry. This mass slug is called the **Treacle**
2. Measurement of V_{oc} determines U and P.
3. The system equations are: 1) Mass Conservation 2) Momentum Conservation 3) Energy Conservation and 4) State (gas) Laws. For a known Area and Magnetic Field (B), coupled with the electromagnetic forcing term measurement, the solution of **Treacle** Pressure, Impulse,Velocity,Density, and Conductivity is produced. It is an analog computer fully solving for the shock variables of a constant area power generator during channel **Treacle** travel.

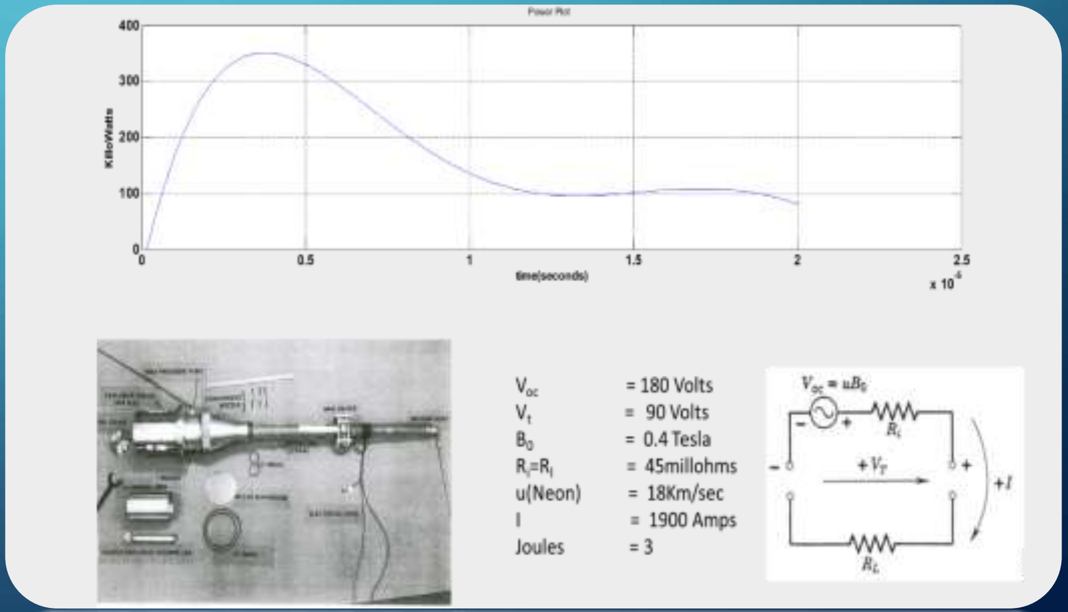


Schlieren (Shadow Graph) Frame of Shock Traveling Left to Right Approaching Input Slit
Homogeneous Treacle Mass
Rarefaction (Exhaust)
Vparticle
Voltage vs. Time Output from 1D Channel
RPG
Volts
3.5
3
2.5
2
1.5
1
0.5
0
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
0.04
Time(seconds)
Electrical Output
N
VAlfvén
Bstatic
S
Discontinuity
Ic
Initial Conditions of Pressure, Temperature, Density the discontinuity Consumes this material
Input Shock Slit
Vshock = Efield/Bstatic
Vparticle = Vshock - VAlfvén
Shock Velocity Vshock is the wave speed on top of a mass added to its overall speed Vparticle and also equals the E Field to B Field ratio.

Multi-Joule Systems

H A Consulting has the demonstrated expertise to utilize a Self Powered Sensor/Fuze as a generator to direct drive detonators, squibs, gas generators and the like . Below are actual tests conducted demonstrating the very high power density of an MGD generator: Here, left figure, 2.5 gigawatts and 1250 Joules each generator into a matched were produced with 0.005 m^2 pulse generators and 350 kilowatts and 3 joules (right figure) were produced into a matched load. These devices utilize the kinetic energy contained in an explosively generated shock wave.





FAQ

- ***<u>What is a shock?</u>*** A shock is described mathematically as a discontinuity and is a quantum event meaning that the action takes place on the time scales and distances associated with the interaction of molecules and electrons. Practically it is the immediate change of a media's environmental conditions of pressure, temperature density and velocity. Media is a free variable or what we are given.
- ***<u>What is a stand alone sensor/fuze?</u>*** A stand alone sensor is a sensor that detects application of an explosive generated impulse within 200 microseconds after a main impulse application, then generates power and energy by utilizing the kinetic energy of the shock in combination with the electrical field energy to fire detonators, squibs and the like.
- ***<u>How does the stand alone sensor/fuze work?</u>*** The sensor works by generating a voltage upon detection of the first shock impulse in the longitudinal series train. Its construction is a rectangular opening slit that allows the initial electrically **conductive** pulse emanated from the explosive event to enter. It is made of permanent magnets with North Pole facing South Pole on two sides of the rectangle and orthogonal, insulated from the magnets poles, positive and negative conductive pickup terminals on the other two sides. The slit area is 3/8" x ¾" wide and the sensor is ¾'' long. It is a Tesla linear motor generator which generates a voltage proportional to not only the speed of the shock but also its density and dynamic pressure, when a conductor (the shock) with velocity passes through the magnetic field while simultaneously touching the

FAQ

- **What is the value of the sensor output and in the event there is no free charge (no conductivity) in the shock media would there be no output from the sensor?**

The sensor as constructed with a ¼ Tesla B Field produces 1.5Volts/Mach. In the event there is no free charge in the media there would be no output during media transit through the magnetic field. However this is not a possibility as the physics of a discontinuity prohibits the situation where free electrons (charge) could not exist. The question is whether or not the sensor's output is dependent on the **amount** of charge which is expressed as media conductivity in mohs/meter. The sensor follows theTesla per unit equation which states: Open Circuit Voltage = B(field)*Media Velocity. As this definition of open circuit voltage is the measurement of voltage into an infinite resistance, in the limit, an infinite

- resistance would require 1/infinity conductivity or one electron. Tesla's equation therefore satisfies the limit. Practically though measurements are subject to stray capacitance, inductance, and wiring resistance and measurement input impedances. These additional parameters call for additional current over one electron. The standard oscilloscope measurement is a 1 Megohm load with a 15 pfarad capacitor in parallel, a long way from infinity. 10X and 100X probes, which resemble more the input to a Field Effect Transistor, are 10 Megohm and 100 Megohm again with 15 pfarad capacitors in parallel. HA Consulting has made unequivocal that the practical call for current from standard circuits would not affect the linearity of the sensor measurement.

FAQ

- **Quantum arguments aside it is still hardly intuitive that a system that requires conductivity has no conductivity dependence. How can this be?**

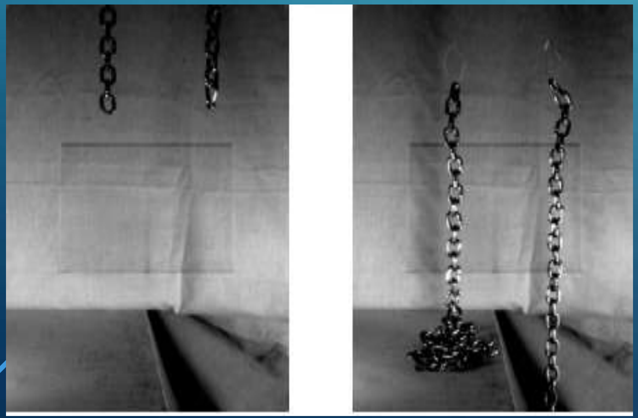
- There is conductivity dependence and it is as described physical call for current constraints, but there is also direct dependence in the power output of the device. Again Tesla's expanded formulation states power output is a function of the square of the product of both media velocity and B Field, but only up to a certain value of conductivity. After that it is not dependent on conductivity rather linear with velocity but still dependent on the B Field squared. This left the fluid dynamics theorists'cold for some 60 years and it was not until the late 1960's that a full and proper theory of a compressible media's transit through a B field was published (REF: Electromagnetodynamics of Fluids – Chapter 11 – by Hughes and Young). To adequately describe the two fluid flow phases and their dependence on conductivity the fluid theorists crafted the unitless Magnetic Reynolds Number which is linearly dependent on the product of conductivity and fluid flow velocity. It conveniently turns out that the boundary between dependence and independence of conductivity is a Magnetic Reynolds Number of 1.

BACK UP SLIDES SHOWING SENSOR MEASUREMENTS AND AN ANALOG

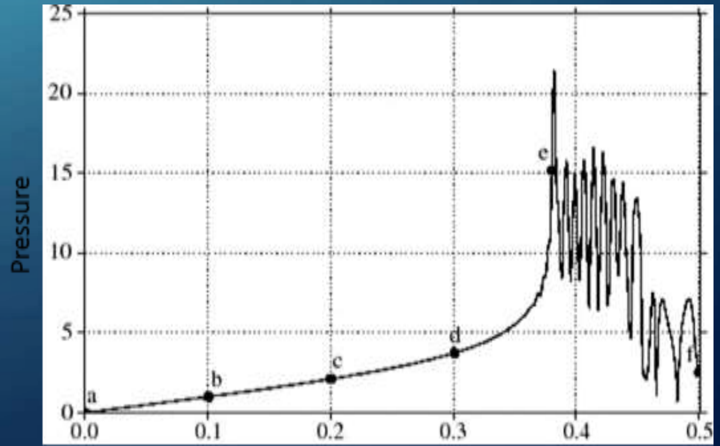
- Falling chain analog
- 4Kg C4
- Shape Charge
- 250 # explosive charge

Falling Chain Analog to Explosive Detonation and ----------Impulse Accumulation

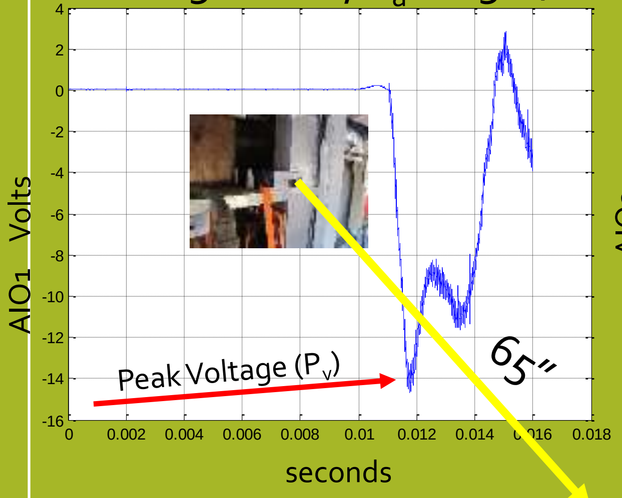
An explosive event burns a solid material producing gases. However in the case of an explosive event the term burning carries a different meaning than thought of when applied to the burning of a common solid material such as wood. The end effects are the same in that both produce gases and heat, but at a highly different rate. **Explosive theory holds that there are two different states in the chemical reaction rate (the rate of change from a solid to a gas) in an explosive material. Deflagration, sometimes called burning, but not to be confused with the burning of everyday material, is a slower event than detonation of solid material by about an order of magnitude. The chemical reaction rate of detonation is in the range of 5 to 10 kilometers per second (Km/sec). This very high reaction rate is the reason a detonated explosive event is so much more energetic than the burning of everyday solids or even deflagration of the material, as kinetic energy goes by the square of the rate or speed of the reaction. When an explosive detonates it produces a train of impulses of different amplitude pressure and time. If allowed to progress in open air the slower pulses of lower pressure amplitudes are overtaken by the faster pulses of higher pressure amplitudes and constructively interact forming one major event called a *shock* which propagates in the open air media. This is called the far field of an explosive event and occurs outside the visible fireball witnessed in the detonation of explosives. Inside the fireball is called the near field of an explosive event. It is chaotic and defined by many impulses spaced in time with different pressure amplitudes and durations.** In the case of an underbody event the action takes place in the near field as this train of impulses stack up (accumulate) on the intervening underbody forming one main impulse applied to the body and defined as t=0. The action is best explained with the following analog.



Each pulse in the near field resulting from the detonation of an explosive is analogous to a chain with different size links falling on a platform. The left figure shows the links accumulating on a platform, stacking up, forming one main impulse and transferring momentum to the platform body. To the right is the graph of the event as the links accumulate



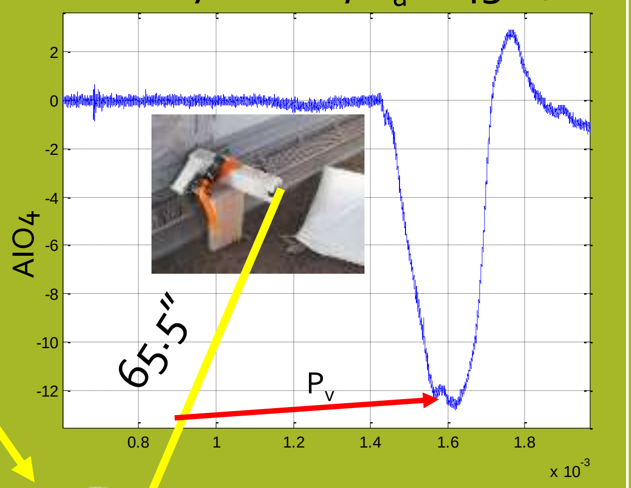
B=0.252 Tesla; V_a=225m/s



B=0.265 Tesla; V_a=250m/s

B=0.256 Tesla; V_a=225m/s

B=0.272 Tesla; V_a=243m/s



Low Cost Measurement of Pressure Inside Occupant Enclosures i.e., Buses, Trains

Vp = 2068; Vs=2293

P = (2068)(2293)(1)(0.00014503) = 688psi

Vp Vs ρ_o

Vp = 2068; Vs=2293

P = (3703)(3953)(1)(0.00014503) = 2123psi

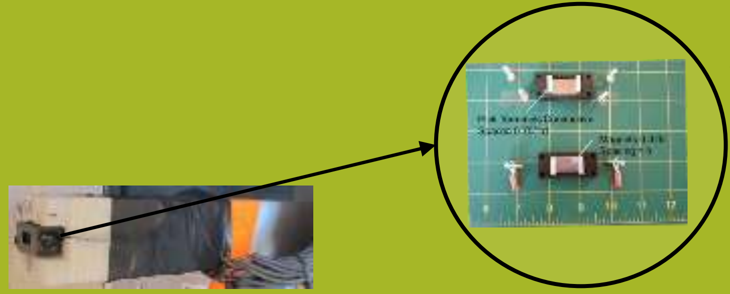
Vp = 2068; Vs=2293

P = (2319)(2544)(1)(0.00014503) = 855psi

Vp = 2068; Vs=2293

P = (2236)(2479)(1)(0.00014503) = 804psi

Pulse Train: Sensor measures first pulse only were the atmospheric conditions in front of pulse are known.



Vs (Shock Vel.) = V_a (Alfvén Vel.) + Vp (Particle Vel.)

V_a = Predetermined Constant related to B Field

ρ_o = Air Density in front of 1st Pulse

Vs = P_v / ((B)(d))

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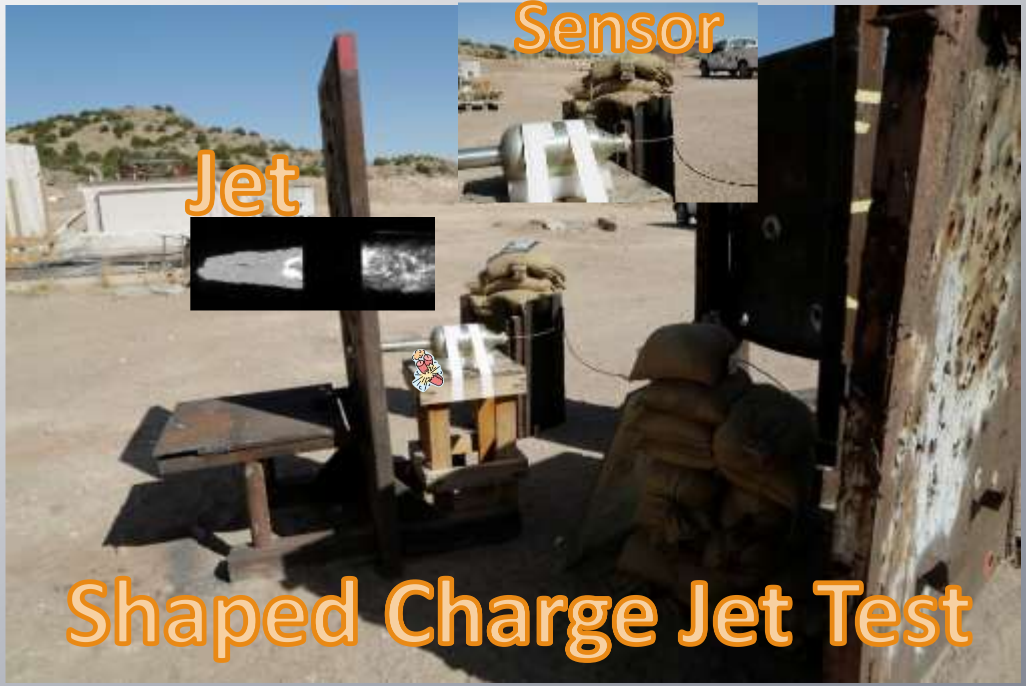
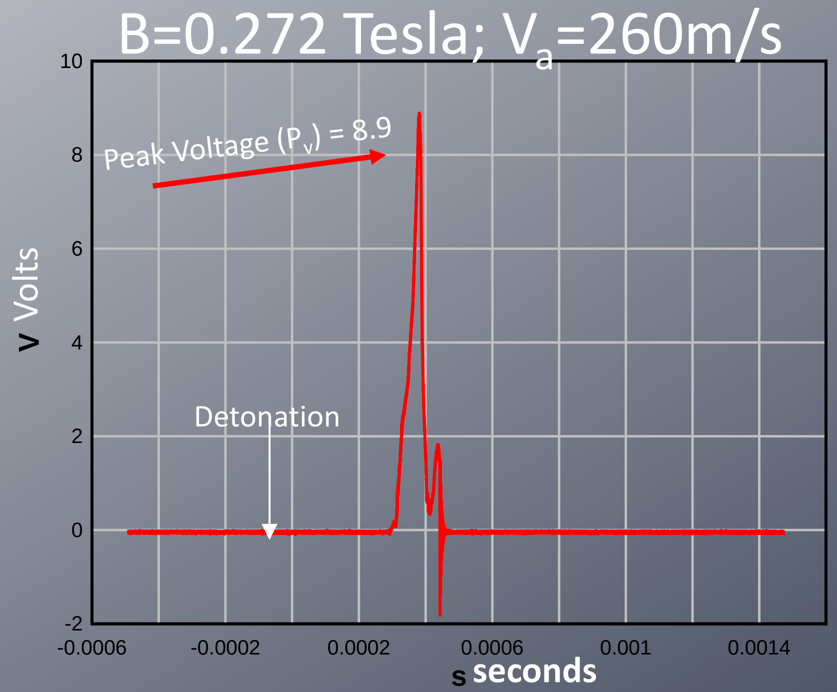
Pressure Surrounding a Cased Explosive Event for Collateral Damage Estimates

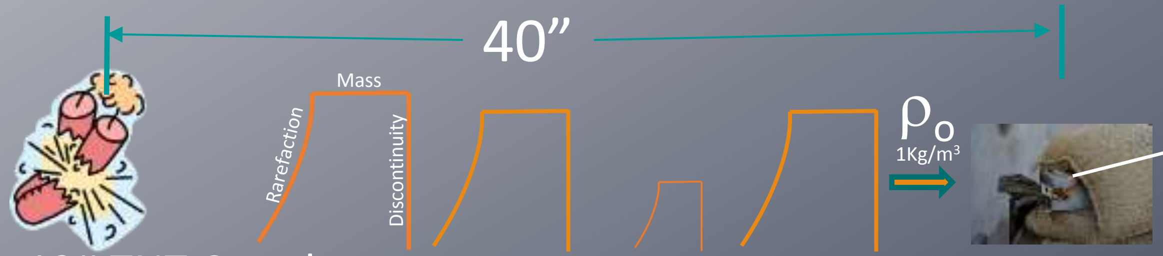




Vp = 1485; Vs=1745

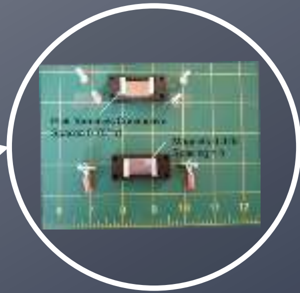
P = (1485)(1745)(1)(0.00014503) = **376psi**

Vp Vs ρ_o



~12# TNT Cased

Pulse Train: Sensor measures first pulse only were the atmospheric conditions in front of pulse are known.



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V_a = Predetermined Constant related to B Field

ρ_o = Air Density in front of 1st Pulse

Vs = P_v / ((B)(d))

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W/EXPLOSIVES
SENSOR OUTPUT FROM 250# SENSOR @ 16'

B=0.318 TESLA; FIRST LINK SHOCK VELOCITY = 16 VOLTS = 2475M/SEC; SENSOR DETECTS BLAST CONSERVATIVELY 125 MICROSECONDS BEFORE IT STARTS TO DESTRUCT; SENSOR MOUNTED MASS ~ 75 POUNDS