EM Gun PROGRAM

Fuzing for Use in an Electromagnetic (EM) Gun

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Background

• EM guns have been studied for many years
• Theoretical benefits (over powder guns) of hypervelocity launch and simplified logistics make EM guns attractive
• Recent advances in pulsed power technology resulted in effort to launch HE projectiles from EM gun
EM Guns

- There are several types of EM guns or launchers, rail guns and several different coil guns.
  - Rail guns are the simplest the most perfected launchers
    - Our testing will use a rail gun
- Rail Guns use the Lorenz force $\vec{F}=i\vec{l} \times \vec{B}$
Fuze Approach

- Design an all mechanical, dual safe PD fuze that uses EM Gun environments to arm
- Test the survivability of typical fuze electronics and EED’s in typical EM launch environment
  - Determine orientation and shielding required to make electronics survive
ARL ½ MJ Rail Gun

- Fuze/Projectile test launcher
- 22mm x 44 mm bore
  - 38 mm scalloped diameter
- Peak Current = 1 MA max
- Gun Length = 2.8 m
Integrated Launch Package, ILP
(the projectile)

- 24.4 mm diameter sub-cal projectile
- Aluminum armature incorporated into rectangular sabot
- Nose fuze ~3” forward of armature
Launch Environment

– Setback ~ 50-60 kGs
– Magnetic Field
  • Changes with current, position and configuration
  • ~ 0.2 Tesla peak at projectile nose for 50kG launch
– Transition & Balloting loads
  • Transition – sudden rise in armature/rail interface and system voltage
  • Transition energy thought to cause balloting
  • Balloting estimated at 20% peak setback
    – Balloting oriented rail to rail
EM Gun Magnetic Field Profile

Distance Downbore From Armature (mm)

Magnetic Field, Bz (T)

Armature Thickness

Committed To Excellence
Mechanical EM Fuze

- Arming environments
  - Setback
  - Magnetic (B) field
- Energy to arm derived from setback
- Function modes
  - PD
  - Inertial graze

Hardware available end of April, 05
Magnetic Lock

• Repelling magnets in rotor
  – Extend past OD to lock rotor

• Magnets aligned with launch B field
  – Fuze clocked to sabot
  – rectangular sabot/launcher provides proper orientation

• At launch, B field re-polarizes 1 magnet
  – After launch magnets attract
  – Rotor released
Magnetic Lock
Magnet selection

- Alnico 5 selected
  - Mechanical strength
  - Magnetic force
  - Magnetization curve
- L/D > 4 & minimum diameter 1/16” drove minimum rotor size
- Alnico 5 magnets tested in ARL “H” fixture
  - ARL “H” fixture simulates launcher magnetic field
  - One magnet re-polarized and magnets attract
Setback, Arming & Initiation

- Setback lock blocks rotor in forward position
- After setback, setback spring becomes arming spring
- Firing pin prevents rotor movement until after launch
- PD mode firing pin driven aft
- Graze mode – rotor moves forward into firing pin
Electronics Testing

• Determine the effects of the magnetic field produced by ARL’s EM Gun on electronics typically used in fuzes
  • Utilized ARL’s H-fixture
  • Test items were not shielded
  • Subjected digital watches to various magnetic field strengths that a fuze in a typical round might experience
  • Also, subjected digital watches to 4X’s the maximum magnetic field strength
    • All units survived
      • Times did not vary from control unit
      • LCD display functioned properly
Simulated EED Testing

• Subjected Littlefuse PicoII fuses to same magnetic fields as watches
  • Two models used, 1.7 and 7.0 ohms, to simulate resistance range of typical EEDs
  • Fusible resistor leads shorted together to form loops of different sizes
  • Fuses did not function - resistance did not change
• Possible Explanations
  • Current induced in fuses too low
  • Pulse duration too short to open fuses
Initial Ballistic Testing

• Inert ILP’s fired with dummy fuzes
• Most rounds showed damage from launch
  – Damage from balloting, rail contact, or arcing?
• Recovered hardware showed erosion where sabots meet
  – One recovered dummy fuze had eroded up to 3/64”
Upcoming Ballistic Testing

• Next test – stronger fins & muzzle shunt
  – Inductive shunt to reduce muzzle arcing
• System issues need to be solved prior to shooting live rounds or fuzes
Summary

- Interior ballistics and current flow needs to be managed at system level.
- Testing to date indicates Electromechanical fuzing to operate within EM gun magnetic field is achievable within the state of the art.
Future Work

• PD fuze testing to commence May 05
• EM gun testing will be limited to inert testing until system issues are resolved