OPTICAL SYSTEM TO CONTROL TERMINATION OF SMALL- AND MEDIUM-CALIBER MUNITIONS


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Presentation
For NDIA 54th Annual Fuze Conference

Kansas City, MO
May 12, 2010
Needs

• Proximity fuzes (PFs) are widely used in large-caliber (>50 mm) artillery shells, aviation bombs, and missile warheads.

• PF initiates ordnance explosive detonation at a given distance from the target.

• Similar control of termination is needed for small-(12-gauge) and medium-caliber (40-mm) munitions in long-range nonlethal applications and in high-lethality airburst applications.
POC Solution

- The best suited fuze is an optical fuze based on a laser triangulation proximity sensor mounted inside a round.
- The laser proximity sensors (LPSs) being developed at POC can respond to a target emerging in front of a flying round at a distance from 0 to 2-3 m with a response time in tens of microseconds.
- Munitions assembled with LPS, does not require weapon modification.
- POC has developed prototypes for 12-gauge (Optical Proximity Sensor - OPS) and 40-mm (Smart Optical Proximity Fuze - SOProF) calibers.
Application Scenarios

Nonlethal

Application of the LPS (OPS) with variable-range kinetic energy munition with inflating bag.

High-Lethality Airburst

LPS (SOProF) installed on a high explosive 40-mm round; detects a target 0 m to 2 m from a projectile and activates electric initiator for airburst.
Laser Triangulation Principle

The transmitted laser beam reflecting from a target located at distances from T1 to T4 causes displacement of the beam image across the active area of the photodetector from position T1PD to T4PD. The beam image reflected from a target in position T4 does not reach the active area of the photodetector.
Laser Triangulation Principle (Cont.)
Laser Triangulation in an Axially Symmetric Configuration

Advantages of axial symmetric arrangement of multiple apertures and photodetectors:

• Better ballistics due to center of gravity being located on the longitudinal axis of a round.
• Higher SNR due to averaging of multiple output signals
POC’s LPS Prototypes

Three generations of OPS prototypes for 12-gauge caliber

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside diameter, mm</td>
<td>17.8</td>
</tr>
<tr>
<td>Length including PC board, mm</td>
<td>19.0</td>
</tr>
<tr>
<td>Weight (without battery), g</td>
<td>10.2</td>
</tr>
<tr>
<td>Distance range, m</td>
<td>3-5</td>
</tr>
<tr>
<td>Light source: Laser diode @ 808 nm</td>
<td>200 mW</td>
</tr>
</tbody>
</table>

Splitting OPS for nonlethal applications.

Power: 6 V
Li/MnO$_2$ battery
LPS Prototypes (Cont.)

LPS (SOProF) assembled in M433 40-mm round model.

Power: 3.7 V Li-ion rechargeable battery
Block diagram of LPS prototype electronic circuitry for 12-gauge round. Light-modulating photo IC provides synchronous light detection, improving SNR and miniaturizing LPS package.
LPS Electronics (Cont.)

Block diagram of LPS prototype electronic circuitry for 40-mm round. Accelerometer functions as a power switch. Light modulation minimizes power consumption.
LPS Performance

Output signals from the photodetector (top curve) and comparator (bottom curve) for different distances to the target.

3 in. 10 in. 12 in.

36 in. 72 in. 96 in.

No response
LPS Performance (Cont.)

Output signals from the photodetector (top curve) and comparator (bottom curve) for different distances to the target.

Voltage threshold supports LPS operation in harsh visibility conditions.
LPS Performance

Angular diagrams of target detection at a distance of 3 m for four fabrics differing in color and texture, covering the target surface.

- Dark red fabric $\pm 49^\circ$
- Dark blue fabric $\pm 52^\circ$
- Pink fabric $\pm 56^\circ$
- Light blue fabric $\pm 69^\circ$
LPS Performance Demonstration

- 12-Gauge OPS
- 40-mm SOPROF

- Goals: Distance Range Verification; Shock Survivability
LPS Performance Demonstration (Cont.)

12-gauge OPS

Target out of range. LED indicator is off.

Target range. LED indicator is On.

Target range. LED indicator is On all the way to the target.

40-mm SOPrOF
# Summary of LPS Performance Demonstration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Bolt path during 1 frame</td>
<td>125 cm</td>
</tr>
<tr>
<td>Bolt speed with OPS assembly (estimated from light track)</td>
<td>47 m/s</td>
</tr>
<tr>
<td>Bolt deceleration while hitting the target (5 cm penetration to full stop)</td>
<td>≈2300 g</td>
</tr>
<tr>
<td>Bolt speed with M433/SOProF assembly (estimated)</td>
<td>45 m/s</td>
</tr>
<tr>
<td>Bolt deceleration while hitting the target (5 cm penetration to full stop)</td>
<td>≈2025 g</td>
</tr>
</tbody>
</table>
Potential LPS Applications

12-gauge Electronic Tag, (Triton Systems)

12-gauge Nonlethal “Fire & Forget,” (Foster-Miller)

12-gauge Long-Range Taser (TASER International)

LPS (OPS, SOProF) POC

40-mm Nonlethal Low-Velocity Round (Metal Storm Inc.)

40-mm Airburst Low-Velocity Round for M203 Launcher (MSI)

40-mm Long-Range Nonlethal High-Velocity Round for MK19 Launcher

RABID (EXQUADRUM, TASER Int.)