HIGH POWER ELECTRONICS
FOR
ARMOR AND ARMAMENT

PRESENTED
BY
Dave Singh
U.S.ARMY RESEARCH LABORATORY
WEAPONS AND MATERIALS RESEARCH DIRECTORATE

AT
EPRI/DARPA

POST SILICON MEGAWATT REVIEW
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Electric Armaments

ELECTROThERMAl CHEMICAL GUN:
• Mostly chemical energy

ELECTROMAGNETIC RAILgun:
• All electric
**PULSED POWER CONDITIONING TECHNOLOGY**

**SWITCH TECHNOLOGY STATUS**

<table>
<thead>
<tr>
<th></th>
<th>SG</th>
<th>TVS</th>
<th>THYRISTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Current-kA</td>
<td>300 (1000)</td>
<td>125 (500)</td>
<td>150 (300)</td>
</tr>
<tr>
<td>Peak Voltage-kV</td>
<td>&gt;100</td>
<td>100</td>
<td>6 (10)</td>
</tr>
<tr>
<td>Action-MA².S</td>
<td>50 (500)</td>
<td>10 (500)</td>
<td>22 (360)</td>
</tr>
<tr>
<td>Voltage Drop-V</td>
<td>50 (200)</td>
<td>100 (400)</td>
<td>&lt;20</td>
</tr>
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*SG - Spark Gap  TVS - Triggered Vacuum Switch*
125 mm THYRISTOR CHARACTERIZATION
INVOLUTED GATE

124 kA at 85 µs

C. H. & H. S. 8/18/98
125 mm THYRISTOR CHARACTERIZATION
INVOLUTED GATE

Power (MW)

Time (s)

Voltage (kV)

C.H & H.S 8/18/98
V anode = 3.5 kV

125 mm THYRISTOR CURRENT
V anode = 3.5 kV

Current (kA)

Voltage (kV)

Time (μS)
Pulse Power Thyristors

**Features**

- Longer Gate Line
- Higher Lifetime
- No Emitter Shorts

**Results**

- Higher di/dt
- Lower Forward Drop
- Faster Plasma Spread

Projected Rating
> 15kA/µs, > 200 kA

Tested To:
> 3.3kA/µs, 175 kA peak
PEBB AC-MODULE
CURRENT

Current (kA)

Time (μS)

0 50 100 150 200 250 300

270 V
509 V
738 V
985 V
1100 V
V charge = 1.12 kV

Current (kA) vs. Time (μS)

- 8000 A² S
- 3200 A² S
V charge = 1.12 kV

Voltage (kV)

Time (μS)

Peak Current
- 5.5 kA
- 7.4 kA
- 8.5 kA
- 10.3 kA
- 13.5 kA
High-Rep Rate Trigger Generator Using PEBB

• Burst Storage Capacitor
  – Supplies energy to recharge spiker and sustainer.
  – Eliminate high power supply for limited burst operation.

• Spiker Circuit
  – Generates high-voltage pulse to breakdown the vacuum switch plasma gun.
  – Supplies 6 kV, 100 ns risetime voltage pulse

• Sustainer Circuit
  – Delivers sustained high-current pulse to drive trigger plasma to close the vacuum switch.
  – Generates 1 kA with a 8 microsecond FWHM pulse.
Burst Performance at 500 pps

Ten shot burst at 500 pps.
(Note time axis is discontinuous between current pulses.)

Detail of the fourth voltage pulse in the 10 shot burst.
The trigger pin breaks down at 2 kV.

Detail of fourth current pulse in the 10 shot burst showing >1 kA current and 8 µs pulse width.
Benefits and Future Directions

- Benefits of using MCTs in repetitive trigger generators
  - High repetition capability.
  - Fast turn-on dI/dt.
  - High peak current capability.
  - Current interruption capability.
  - Compact, light-weight, high-voltage triggering capability for electric weapon systems.

- Future Directions
  - Further reduce volume by utilizing MCT current interruption capability to eliminating PFN portion of the sustainer circuit
SWITCH REQUIREMENTS

- POWER DENSITY > 20Mw/m³
- DI/DT > 10ka/µs
- LIFE TIME > 1000 Bursts
- MODULARITY Series/Parallel
- RELIABILITY Graceful Degradation
- INTELLIGENCE Diagnostics/ Self Prot.
- CONTROL µP/Laser
- HIGH TEMP. OPERATION > 300 C
  Reduce Thermal Management - 6 Fold

BATTLE FIELD HARDENED
SUMMARY

High Power Electronics is Enabling Technology for Future Combat Platforms, which are envisioned to be compact and light; yet must be more MOBILE, LETHAL and SURVIVABLE. Silicon based Switch development is necessary to aid accelerated development of future systems and novel material Switches.

ARL-WMRD has mission to develop technologies to enhance LETHALITY AND SURVIVABILITY of FUTURE COMBAT PLATFORMS.