Performance Enhancements to the Legacy FMU-139 Bomb Fuze

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FMU-139 Chronology

- FMU-139/B and A/B
  - Full scale procurement contract in 1984
  - Last procurement contract was awarded in 1992
  - Build to print design
  - Joint Service Navy lead
  - Motorola Manufacturer
- FMU-139 B/B
  - Navy reboostered Motorola A/B fuzes and converted to B/B

FMU-139 Chronology (Cont.)

- After government contracts Motorola continued commercial sales
- Withdrew from fuzing market in 1997
  - Foreign user stocks declined
  - Commercial sales market

KDI FMU-139B/B

- Developed Jan 2001 to Feb 2003
  - Obsolete components replaced
  - Microprocessor replaced by gate arrays
- FMU-139 is NAVAIR nomenclature
  - Refers to build to print configuration
  - Could no longer be built

KDI FMU-139 B/B (Cont.)

- Converted design requirements and build to print data package into a performance specification and DCD
- Evaluated submitted designs for conformance to requirements under CSA

FMU-139 New Procurement

- 2003-Navy determined need for additional FMU-139B/Bs
  - Competitive Procurement
- KDI awarded a production contract in May 2003 for 48,774 fuzes

FMU-139 B/B Limitations

- Operational life in FFCS is 1 minute, Max
  - Sufficient for free fall weapons
  - Insufficient for JDAM
- Limited tolerance for power drop outs during operation with FZU-48
  - JDAM high altitude operation

This FMU-139 A/B may have exceeded it’s service life !

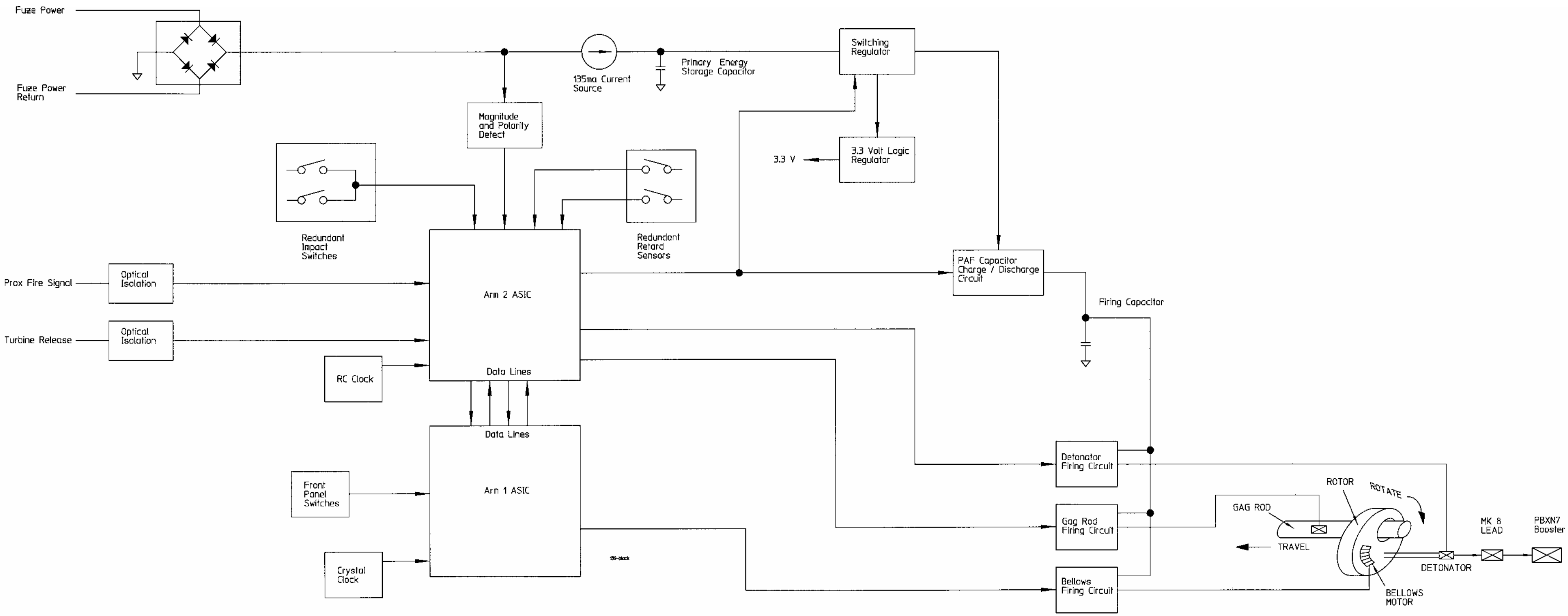
FMU-139 C/B Chronology

- FMU-139 C/B
  - Navy inquired into the feasibility of extending the FFCS operational life of a FMU-139 B/B from 1-minute to 4-minutes. (July 2003)
  - Navy modified production contract to procure FMU-139 C/B in November 2003.
  - New performance specification PMA-201-03-003 issued March 2004

What performance enhancements are incorporated into the FMU-139 C/B ?

- 240 second FFCS life using the same input current budget available to the FMU-152
- Electrical interlock to preclude out of sequence arming
- Numerous manufacturing yield improvements. (Lessons learned from building the FMU-139 B/B)

Block Diagram of FMU-139 C/B



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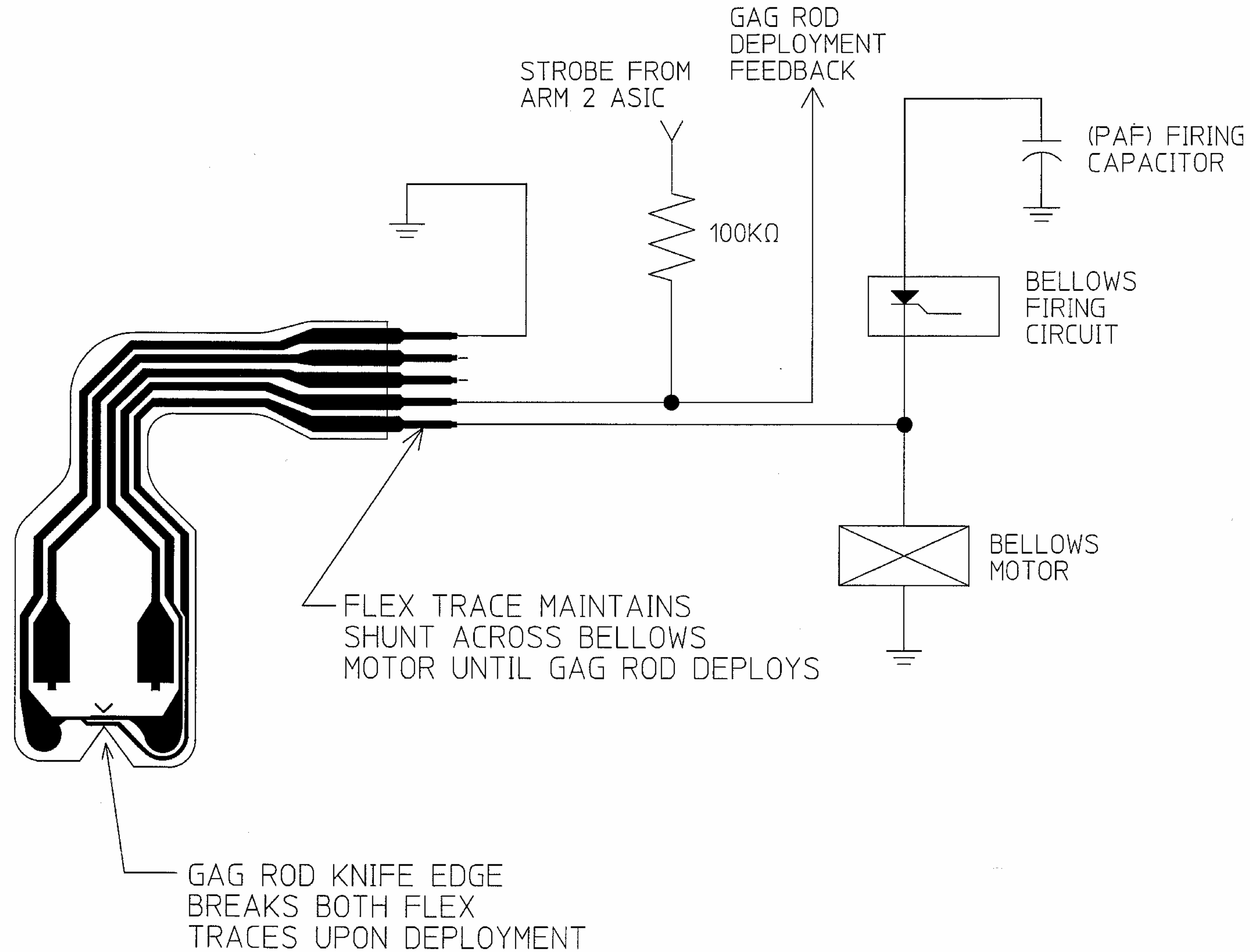
Safety Enhancement

- The Safety Community is concerned that the FMU-139 B/B gag rod is not sufficient to mechanically lock the rotor. The issues are two-fold:
  - If an ESD event or some other remote anomaly energizes the gag rod and bellows simultaneously, Crane has demonstrated that the fuze may arm.
  - If an ESD event or other anomaly fires the bellows out of sequence, this error is not sensed, because the gag rod prevents sufficient rotation. If the gag rod is subsequently commanded to fire, the rotor rotates because of residual gas pressure stored in the bellows motor.

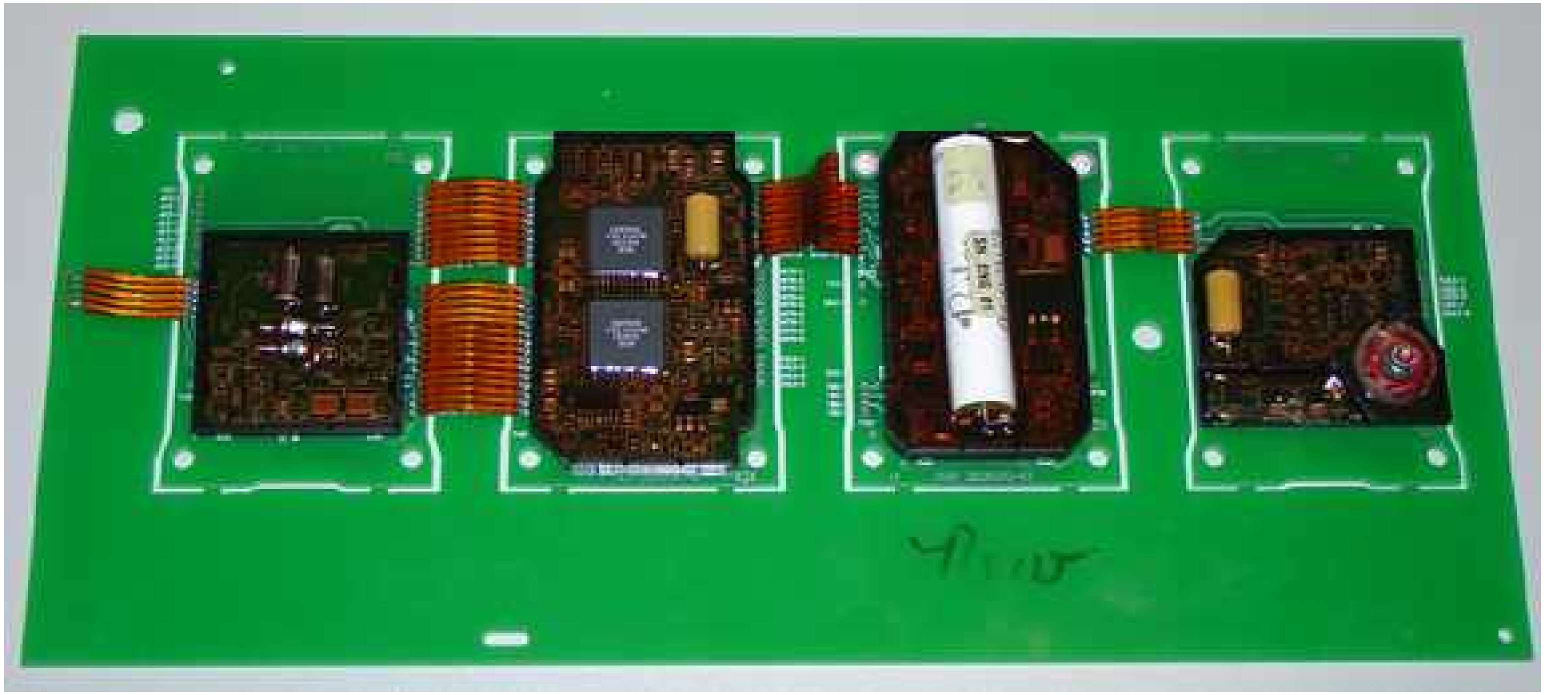
Safety Enhancement - Continued

- KDI elected to mitigate this concern by maintaining a short circuit across the bellows motor until it is time to arm the fuze.
- The gag rod now serves two purposes:
  - As a mechanical lock to prevent rotation of the bellows motor.
  - As an electrical interlock, because it shunts the electrical input of the bellows motor.
- The gag rod interrupts or “breaks” the shunt across the bellows motor, when it extends.

Pictorial Description of New Interlock



Prototype of FMU-139 C/B



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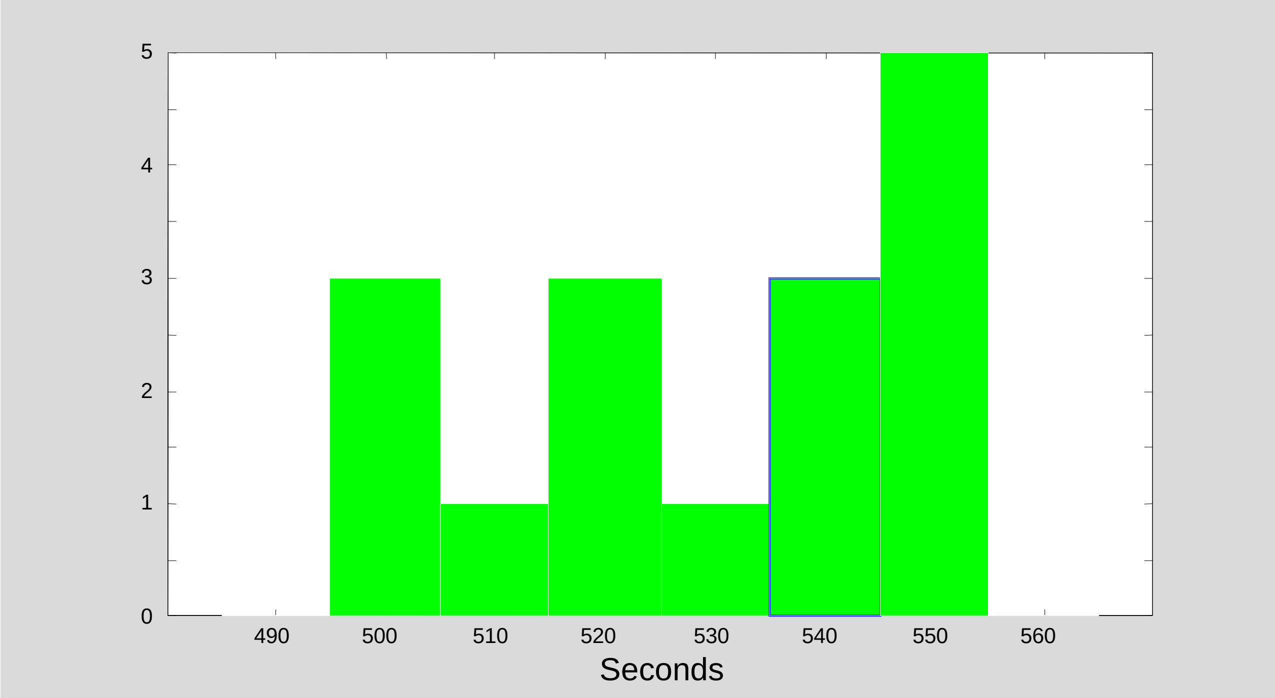
Histogram of FMU-139 C/B Power Supply Life (Ambient)

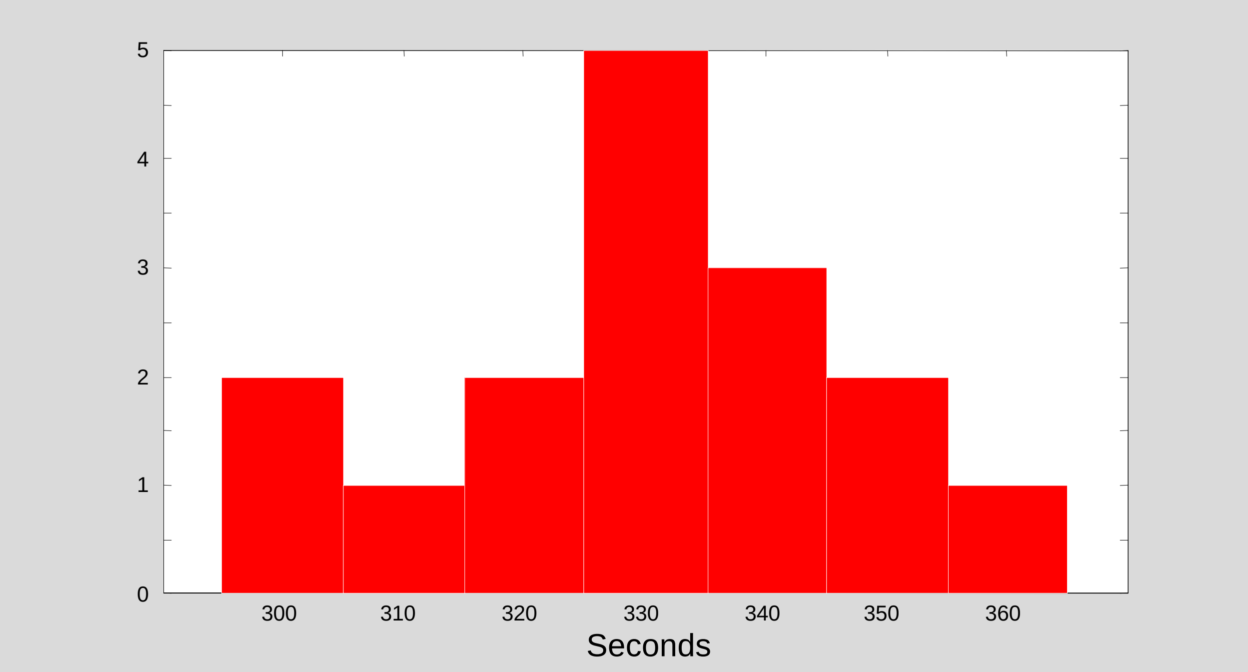


Power supply life is a conservative measure of fuze operational life. (1 Megohm loading of 3.3 volt buss)

Test conditions: FFCS pulse = 195 V, 15 ms   Temperature = 68°F

Population = 16 fuze panels   AVG = 529 seconds (8 minutes, 49 seconds)

Histogram of FMU-139 C/B Power Supply Life (160°F)



Power supply life is a conservative measure of fuze operational life. (1 Megohm loading of 3.3 volt buss)

Test conditions: FFCS pulse = 195 V, 15 ms   Temperature = 160°F

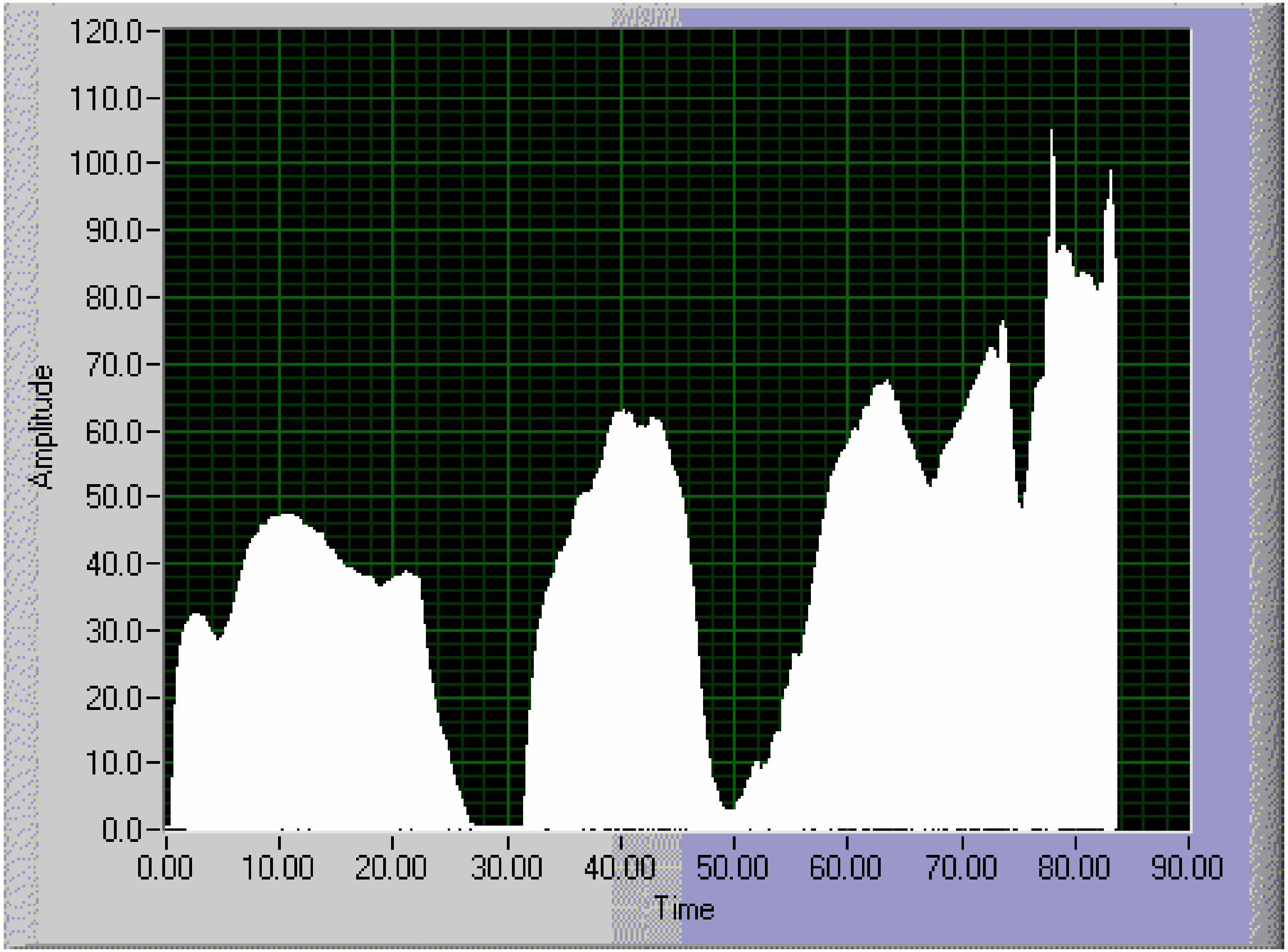
Population = 16 fuze panels   AVG = 331 seconds (5 minutes, 31 seconds)

Discussion of HALA Performance

- HALA = High Altitude Low Airspeed

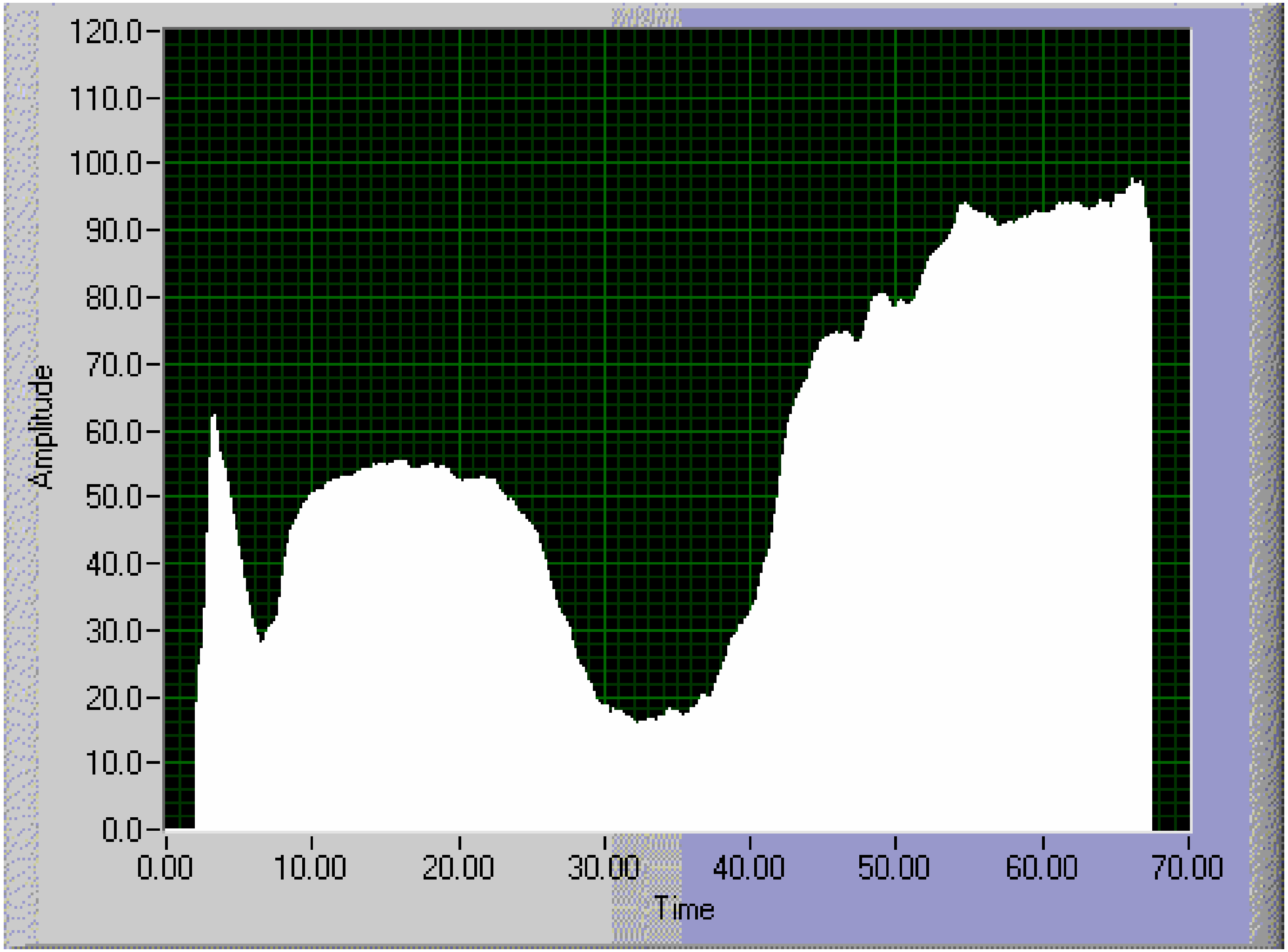
- With weapon systems like JDAM, in-flight maneuvers can starve airflow to the FZU-48 turbine. See the following slides for examples of “drop-outs” and “brown-outs”.

JDAM Flight Test Data Example 1
(FZU-55/B with a simulated FMU-139 load)

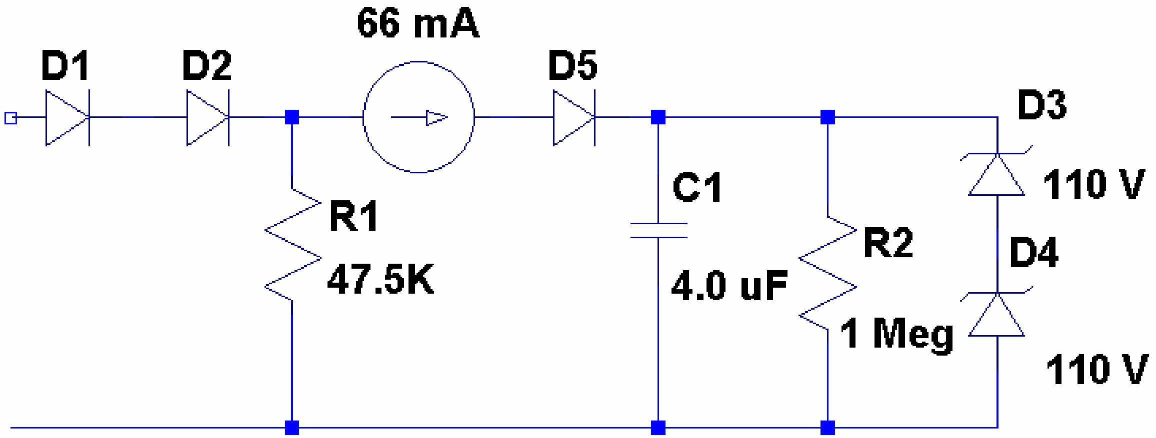


JDAM Flight Test Data Example 2

(FZU-55/B with a simulated FMU-139 load)



Simplified Schematic of FMU-139 Simulated Load



FMU-139 C/B Lab Example

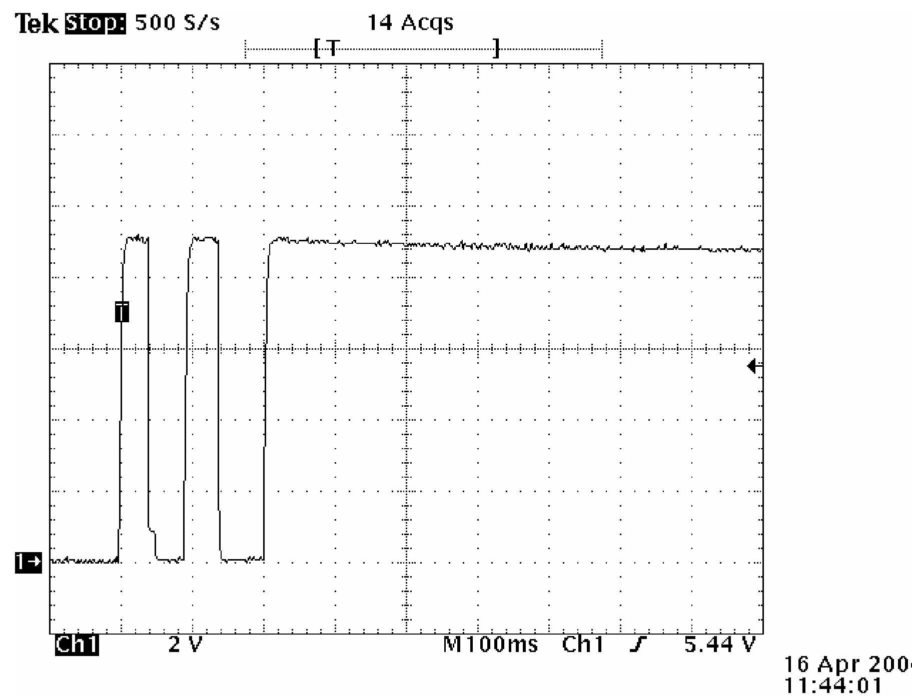
- HALA Simulation Procedure
  – Set low drag arm switch to 20 seconds.
  – Apply 1.6 seconds of turbine power to the fuze, at peak amplitudes of 100, 80, 60, and 40 volts.
  – Remove power and turbine release.
  – Monitor the firing capacitor to see if the fuze arms.
  – Monitor the fuze operational life.

Results of HALA Laboratory Experiment on S/N ENG08

Peak Amplitude (Volts)	Frequency (Hz)	Did the Fuze Arm ?	Operational Life
100	6097	Yes, See Oscillograph 1	44.6 seconds
80.0	6192	Yes, See Oscillograph 2	21.1 seconds
60.4	958	No, Gag rod deployed	20.6 seconds
39.6	1040	No	14.9 seconds

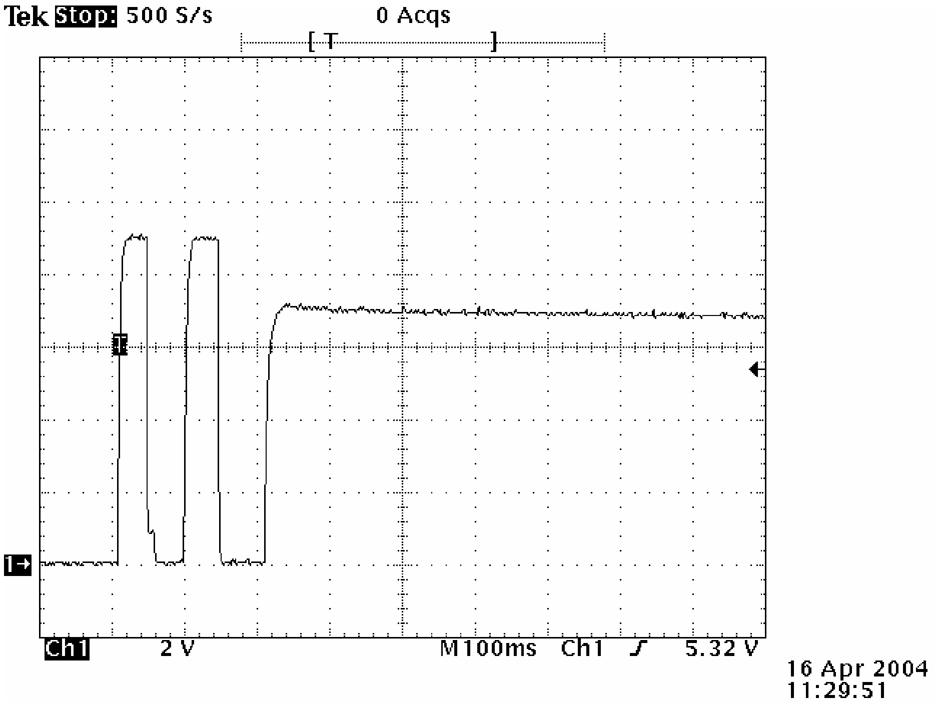
Oscillograph 1
HALA Lab Simulation

- Fuze powered with a half-wave rectified sinusoid of 100 Vpk, 6097 Hz, 1.6 seconds duration.
- Note: PAF capacitor charges to full 9.0 volt amplitude. (3 times)



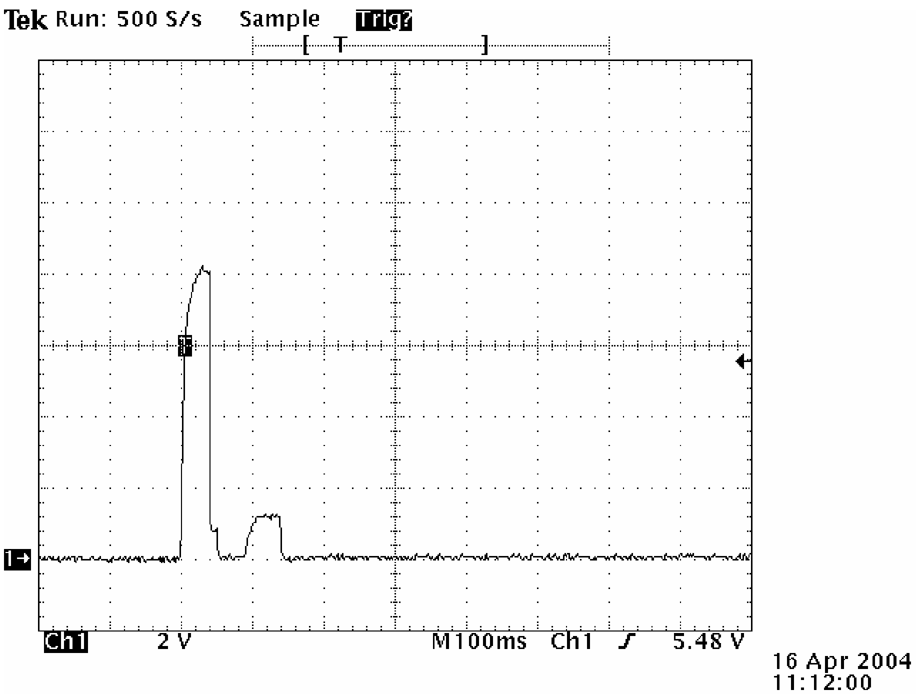
Oscillograph 2
HALA Lab Simulation

- Fuze powered with a half-wave rectified sinusoid of 80 Vpk, 6192 Hz, 1.6 seconds duration.
- Note: Fuze arms, but runs out of energy charging the PAF capacitor a third time.



Oscillograph 3
HALA Lab Simulation

- Fuze powered with a half-wave rectified sinusoid of 60.4 Vpk, 958 Hz, 1.6 seconds duration.
- Note: Fuze runs out of energy after deploying the gag rod.



FMU-139 C/B HALA Summary

- Improved performance over previous generations of the FMU-139.
- Will "coast" through power dropouts of 10 seconds duration, if it occurs prior to arming.
- Will "coast" through power dropouts during the 230 ms charging sequence, if the main energy storage capacitor exceeds 80 volts at arm time.