TEAM FUZING

SEI | DAYRON | KDI | RAYMOND

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Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
16Apr2001	N/A	-

Title and Subtitle Mitigation of FMU-139 Component Obsolescence	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Minnich, John N.; Lewis, Ted	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) KDI Electrical Engineer	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es) NDIA (National Defense Industrial Assocation) 211 Wilson BLvd., Ste. 400 Arlington, VA 22201-3061	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes Proceedings from The 45th Annual Fuze Conference, 16-18 April 2001 Sponsored by NDIA, The original document contains color images.	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 19	

Programme Objectives

- Obsolescence
- Tooling
- Test Gear
- Safety
- Reliability
- Qualification
- 1st Article
- Production

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Qualification Programme

Sub System Tests

HARDWARE

3 off
sub-assys
(Electronic Module & Cover Plate)
KDI

3 off
sub-assys
(S&A Module)
RAYMOND

3 off
Vibration
DAYRON

3 off
sub-assys
(Booster)
SEI

ENVIRONMENT INTERNAL

QUALIFICATION TESTS

a) 3 hrs hot temperature (+85°C)

b) 3 hrs cold temperature (-40°C)

3 Systems -Dayron
3 Boosters - SEI

- 3 hrs random vibration ($0.04g^2$/Hz between 20 Hz and 2 kHz) (Hot/Cold)

a) 1.5 hrs hot temperature (+85°C)

b) 1.5 hrs cold temperature (-40°C)

INTERNAL TEST (TEST/INSPECTION)

KDI
a) Visual Inspection - Pre
b) Functional Test -Pre
c) Visual Inspection - Post
d) Functional Test - Post

RAYMOND
a) Visual Inspection - Pre
b) Functional Test -Pre
c) Visual Inspection - Post
d) Functional Test - Post

DAYRON
a) Visual Inspection – Pre
b) Functional Test -Pre
c) Visual Inspection – Post
d) Functional Test - Post

SEI
a) Visual Inspection prior to test
b) Visual Inspection following test
c) Firing into witness plate
d) Evaluation results

Sequence 1

a) & b) prior to test

Salt Fog

LIVE 3 off	INERT 3 off
a) & b)	a) & b)

Ascertains the ability to resist the effects of a moist, salt-laden atmosphere.
Subjected to a specified controlled environment for 24 hours.
(MIL-STD 331A Test 107.1)

a) Visual check
b) Impedance check

Contamination

LIVE 3 off	INERT 3 off
a) & b)	a) & b)

Determines the resistance of equipment to contamination from fuels, lubricants, hydraulic fluids, de-icers, solvents, fire-fighting agents & fresh/saltwater.
(Def Stan 00-35)

a) Visual check
b) Impedance check

Accelerated Ageing

LIVE 3 off	INERT 3 off
a), b), c), d)	a), b), c), e)

To determine the ability of equipment to withstand prolonged storage at extreme (hot & cold) temperatures.
(MIL-STD 331A Test 112.1 Procdr. 1)

a) Visual check
b) Impedance check
c) Leak Test
d) Fired
e) Strip & Examine

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FMU-139B/B

- Further contract for 3000 FMU139B/B fuzes for a European country.
- Need to address the Power consumption issue to meet the FFCS requirement for the Navy.
- Potential further orders for other European and Middle/Far East Countries.

FMU-139 B/B

Mitigation of FMU-139 Component Obsolescence

John N. Minnich, KDI Electrical Engineer

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FMU-139 Chronology

- FMU-139A/B
  - Full scale procurement commenced in 1985
  - Last procurement was in 1993
- SAU - A FMU-139A/B derivative
  - Original build circa 1989-1992
  - Team Fuzing awarded contract in 1999, delivered units in 2000.

Two Major Design Challenges

- Replacing the obsolete 4-bit microcontroller.
  - Reverse engineering the logic without source code.

- Improving the operating duration when powered in FFCS mode.

Replacing the Microcontroller

- FMU-139 A/B based upon COP320C
  - 4 bit, CMOS design
  - Industrial temp range (-40 °C to 85 °C)
  - Low current: 100 µA at 5V with f_{clk} = 32 KHz

- KDI evaluated 8-bit µcontrollers and FPGAs
  - Architecture A: 8-bit µcontroller + ASIC
  - Architecture B: Two FPGAs / ASICs

Reverse engineering the fuze logic.

- Drawing package did not include source code.
  - ROM Object code available as printed media only !

- KDI attempted to reverse assemble this ROM
  - Output is uncommented assembly code.
  - Output appeared to have reverse assembly errors.

- KDI abandoned the µcontroller approach due to these issues.

What legacy documentation was available to KDI?

- FMU-139A/B Mil. spec. MIL-F-85815A(AS)
  - FFCS and Turbine operating modes
  - High & low drag arm times
  - Impact or proximity detection requirements
  - Impact or Prox function delay timing
- Navy DWG package 1379ASxxx
- SAU DWG package SK105xxxx

What information was missing ?

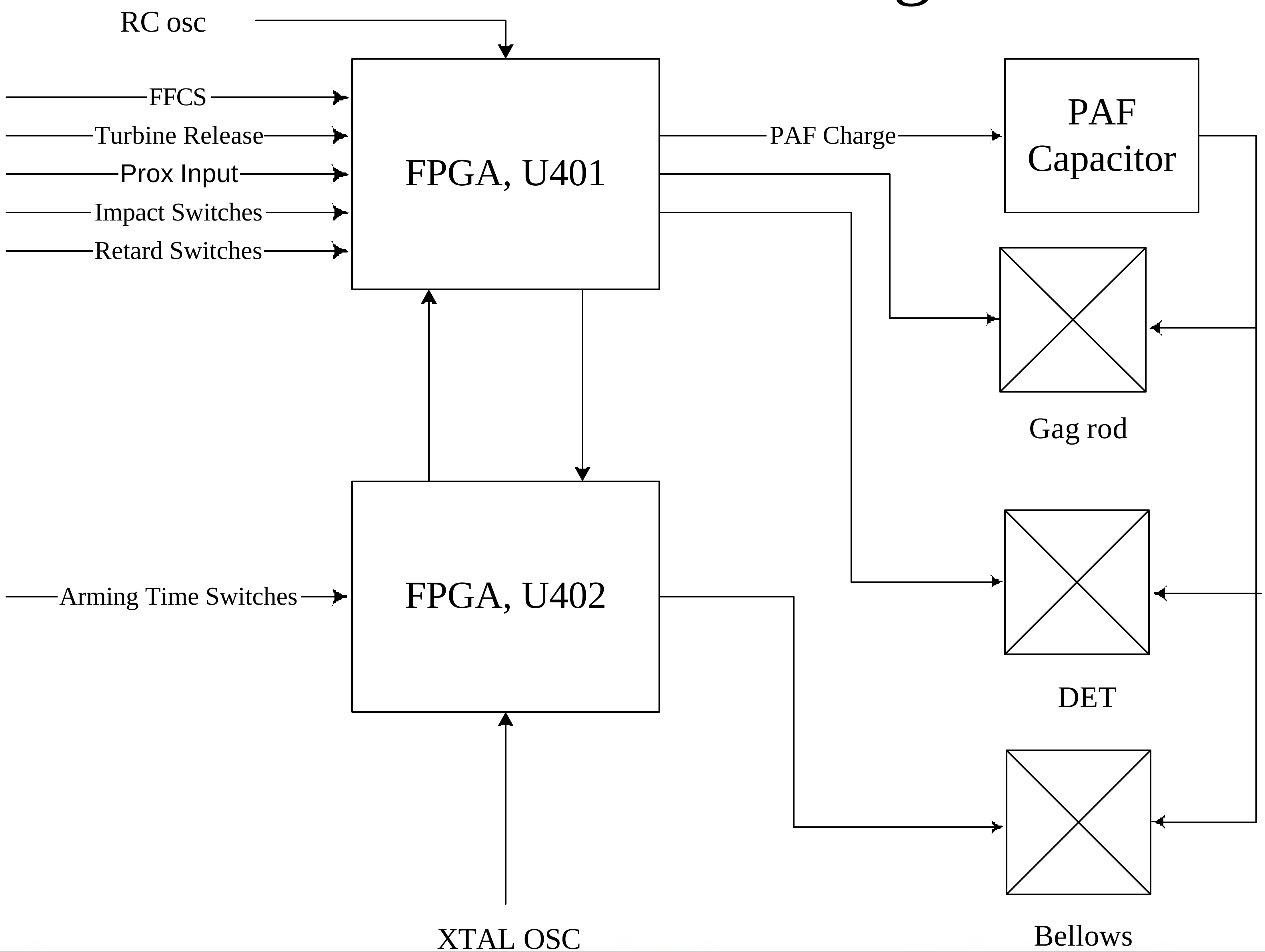
- Drawing package did not include source code.
  - Internal self tests
  - Detailed DUD logic requirements
  - Digital filtering / signal conditioning of inputs

To address these "holes" KDI requested a Commercial Service Agreement with the Navy

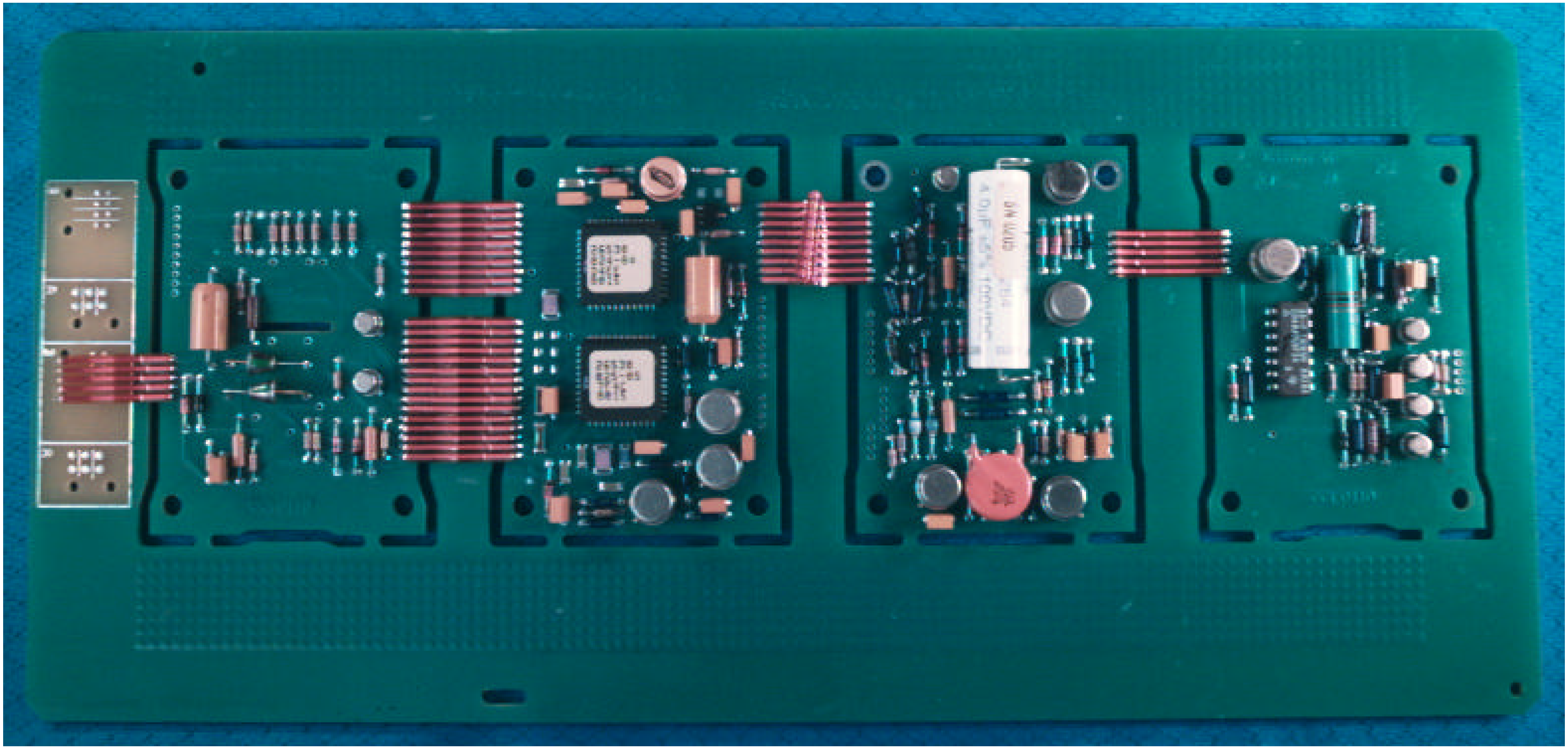
SAU Implementation

- 2 FPGAs replace the µcontroller and ASIC
  - FPGA, U_{402} initiates Gag rod and DET circuitry
  - FPGA, U_{401} initiates Bellows circuitry
- Switching regulator based on FMU-139 A/B "JANTX" implementation rather than SAU
- Components are predominantly "through-hole"

FPGA Partitioning



SAU Production Panel



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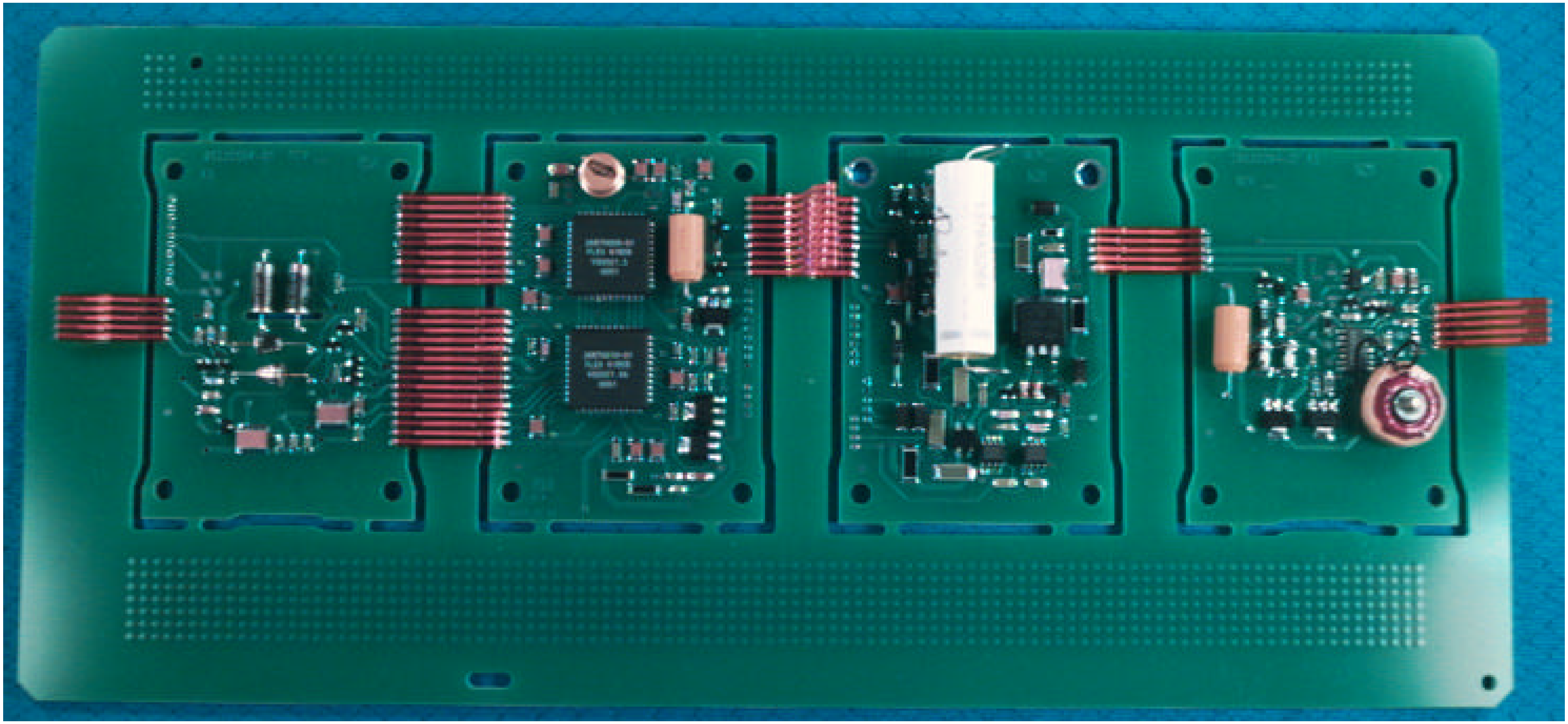
FMU-139B/B Implementation

- 2 ASICs replace the SAU FPGAs
- KDI improved the switching regulator
  - Higher efficiency toroidal inductor
  - All 3 select resistors eliminated
- Components are predominantly surface mount

FMU-139 B/B Prototype Panel



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FFCS Mode Energy Balance

$$\frac{1}{2} C_1 V_1^2 = \frac{3}{2} C_2 V_2^2 + (V_{bus})(i_{ave})(t)$$

C1 ➔ Main energy storage capacitor
C2 ➔ PAF capacitor

Let: $C_1 = 4.0\ \mu F$, $C_2 = 47\ \mu F$
$V_1 = 195$, $V_2 = 9$, $V_{bus} = 3.8$

For: $t = 60$ seconds, $i_{ave} = 308\ \mu A$

Benefits of the Team Fuzing Design Changes

- Operating duration when powered in FFCS mode exceeds the original FMU-139 A/B
- Extended operating duration facilitates higher altitude bomb release
- Modern and reliable manufacturing process.
- Potential cost reduction.
- Based on proven design.