An Integrated Flight Termination Receiver Decoder and Flight Termination Safe and Arm

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to:
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Background
KAMAN Aerospace

Joint Advanced Missile Instrumentation (JAMI)
Flight Termination Safe and Arm (FTSA)

• Cooperative Research and Development Agreement
  - Raymond Engineering Operations (REO)
  - Signed 12 April 1999

• Division of Responsibilities
  - China Lake
    • Electrical/Explosive Design and Development
    • Environmental Testing
  - REO
    • Packaging
    • Hardware Manufacturing

• Under Development, Proof-of-Design Phase
Integrated FTRD / FTS Benefits

- Standardization
- Off-the-Shelf Availability
- Low Unit Cost
- Small Size & Weight
- Low Power Consumption
JAMI FTSA Background

- Compliant With RCC 319-99 (Tailored)
- Factory Programmable For Multiple Applications
- Small Size (~10in³/unit)
- Low Cost DTUPC
- Qualified To “Worst Case” Environmental Levels
  - Based on Environments of Potential Users
- Removable Explosives (EFI, Etc.)
- Fully Testable (Including HV Output)
Block Diagram of JAMI FTSA

Factory Programmable Inputs
- Programming Computer
- LPT1 Communication Bus

Command Destruct Receiver 1
- Terminate
- Tone Monitor 1
- Arm Enable

Command Destruct Receiver 2
- Tone Monitor 2
- Accel Test Input
- Umbilical Disconnect
- Secondary FTSA Battery Monitor

Battery

FTSA
- EEPROM
- Gate Array A
- Gate Array B
- Accelerometer
- A/D Converter
- Regulation
- Fireset
- High Voltage Converter

TM
- Arm Status
- First Motion
- Safe Sep. Status
- Fire Status
- System Operational
- Failsafe Status
- HV Status

TERMINATE
Universal FTRD SBIR PHASE 1 Team

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**SBIR** Contract No. DAAB07-02-C-L602
• Assess feasibility of developing, and performance of a standardized universal FTRD within the constraints of RCC 319-99

• Detail an optimum architecture for the FTRD

• Determine the feasibility of an Integrated FTRD/ FTSA

• Phase I Completed

• Phase II proposal submitted, November 05, 2002
Phase II and III Plan

• Proposed Phase II (submitted 11/05/02)
  – 19-month plan to design and build first-pass RFIC
  – CDR of circuit design/layout at 10 months
  – First silicon at 16 months
  – Final report at 19 months, after Phase III evaluation

• Concurrent Phase III (Kaman REO funding)
  – 18-month plan with most activity in last seven months
  – Incorporate Kaman FTRD requirements and design-for-manufacturability at the outset
Universal Flight Termination System

FTS

FTRD

MTM Universal Outputs

ARM TERMINATE MONITOR OPTIONAL

FTSA

TERMINATION DEVICE

TELEMETRY TRANSMITTER

BAT

90°
Universal FTRD Requirements

- Compliant With RCC 319-99 Tailored and 313-01
- Factory Programmable for Multiple Applications
- Small Size – Compatible with JAMI FTSA Area
- Low Cost DTUPC
- Designed to “Worst Case” Environmental Levels
  - Based on Environments of Potential Users
- Fully Testable
Standard Flight Termination and Receiver Decoder (FTRD)

FTRD

DOWNCONVERTER

RFIC

POWER CONDITIONER

SSTO

FM AUDIO

FM DEMOD

DSP

CONFIG INPUT

POWER

TONE DETECT

DSP

COMMAND DECODER

DSP

nvSRAM

OUTPUT CONDITION/PROTECTION

ARM, TERMINATE, MONITOR TELEMETRY & USER DEFINED OUTPUTS
FTRD Functions

- Detect and lock to command signal
- Detect RCC signals
- Decode tones and sequences (including ARM, TERMINATE, MONITOR, OPTIONAL, CHECK CHANNEL)
- Output commands (ARM, TERMINATE, etc.)
- Output telemetry signals
- Provide programmable interface
- Support installation and checkout testing
- Support sensitivity testing
- Support Day-of-Use check
- Commanded and power-up self-test
FTRD and FTSA Programmability

**FTRD Programmability**

- Command frequency (406-450 MHz), 0.5 MHz resolution
- Fail-safe mode
  - Fail-safe enable / disable
  - Three-tone mode (FTSA) also provides this operating mode
    - Loss of RF signal, threshold and delay timer
    - Loss of power, threshold, delay timer
  - Four-tone mode
    - Fail-safe enabled / disabled by preset RCC tones

**FTSA Programmability**

- Failsafe Enable
  - Loss of Monitor (tone drop out time)
  - Loss of Power (Minimum BAT Volt)
- First Motion Enable
  - First Motion Valid Time
- Acceleration Enable
  - Axis of Acceleration
  - Acceleration Level
- Umbilical Disconnect Enable
- Safe Separation Time
- Arm Enable
- Command Arm (TBD)
Programmable Outputs
- RCC tone output mapping
- Tone sequence output mapping
- Response time, delay time
- Secure mode ARM and TERMINATE sequence programming

Self-test tailoring
Telemetry signal command output mapping
Enable valid tone frequencies

Programmable Outputs
- Flight Destruct (Explosive)
- Safe/Arm Status
- Fire Status
- Safe Separation Status
- First Motion Status
- System Operational
- Failsafe Status
FTRD Approach

• Single SiGe RFIC
  – Two stage down-converter to baseband I/Q outputs
  – Low-power and minimal external components
  – Low-cost
• Synthesized 1\textsuperscript{st} LO for tuning over 406-450 MHz
• Low-power COTS DSP
  – Performs IF filtering, FM demodulation, and tone detection
  – Supports proposed EFTS waveform with minimal reprogramming
Preliminary FTRD Board Layout

IF Demod with DSP tone detect (most components)

1st IF Filter

2nd IF Filters

Discriminator

TXCO

RFIC

Front End Filter

ADC

DSP

Voltage Regulators
**Integrated FTRD/FTSA Summary**

**FTRD**
- Will meet Performance Requirements of JAMI and RCC 319-99 Tailored
- Designed to Fit within FTSA Module Width and Length
- Size: 2.8” x 2.8” x 0.375”
- Weight: < 5 ounces
- Based on Environments of Potential Users
- Power: 0.6 W
- *Can Support Proposed EFTS Waveform and High Alphabet*

**FTSA**
- Compliant With RCC 319-99 (Tailored)
- Factory Programmable For Multiple Applications
- Small Size (~10in³/unit)
- Low Cost DTUPC
- Qualified To “Worst Case” Environmental Levels
  - Based on Environments of Potential Users
- Removable Explosives (EFI, Etc.)
- Fully Testable (Including HV Output)