IMPLEMENTING A TACTICAL TELEMETRY STYSTEM FOR MULTIPLE LAUNCH ROCKET SYSTEM (MLRS) STOCKPILE RELIABILITY TESTING

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ABSTRACT

The Precision Fires Rocket and Missile Systems (PFRMS) Program Office continually undertakes Stockpile Reliability Testing (SRP) to ensure the validity of the accumulated weapons and increase the shelf life of these weapon systems. MLRS is a legacy weapon system that has been undergoing SRP testing for over 20 years. The PFRMS Program Office has a need for a miniature Tactical Telemetry System that will monitor the fuze performance of the MLRS Rocket during SRP testing. This paper will address a technical approach of how a small Tactical Telemetry System could be built to meet this requirement. The Tactical Telemetry system proposed in this paper will monitor fuze functions, operate across the wide environmental spectrum of the SRP tests, and physically fit in the nose area without altering the overall tactical rocket appearance or operation.

KEYWORDS

Stockpile Reliability Testing (SRP), Tactical Telemetry System (TTS), Multiplexer (MUX), Analog to Digital Converter (ADC), Complex Programmable Logic Device (CPLD)

INTRODUCTION

A Tactical Telemetry System to monitor fuze performance of the MLRS Rocket during SRP testing presents a myriad of design problems. Size is the major design constraint, as there is approximately 20 cubic inches in which a telemetry transmitter, PCM encoder, signal conditioning electronics, battery, and S-Band antenna must fit. Figure 1 shows the conical nature of the Fuze cavity in which the TTS will be mounted. To further complicate matters the TTS must be able to survive all of the environmental stresses that a Tactical SRP MLRS round must endure. The primary environmental concern is cold testing (-34ºC) due to the size constraints of the TTS and its corresponding battery. Another concern is not altering the overall tactical rocket appearance or operation. These concerns purport multiple problems such as antenna design, how to turn on the TTS (no umbilical), and mounting the TTS.

Figure 1: MLRS Fuze Cavity

Telemetry Transmitter

The TTS will utilize the MACOM MA06836 transmitter. The transmitter was developed by MACOM in cooperation with the CTEIP HSTSS Program. The MA06836 is a half watt transmitter that is 1.125 inches square. The transmitter is frequency programmable across the entire lower S-Band in .5 MHz intervals and is programmed via a 10 header. This transmitter was chosen for the MLRS TTS primarily for its size. Figure 2 is a picture of the MA06836 compared with a nickel. The MA06836 has an on board linear voltage regulator for use in a 3.3 Volt system or a 5 Volt system. Preceding variants of this transmitter have been flight tested successfully by several HSTSS partners [1].

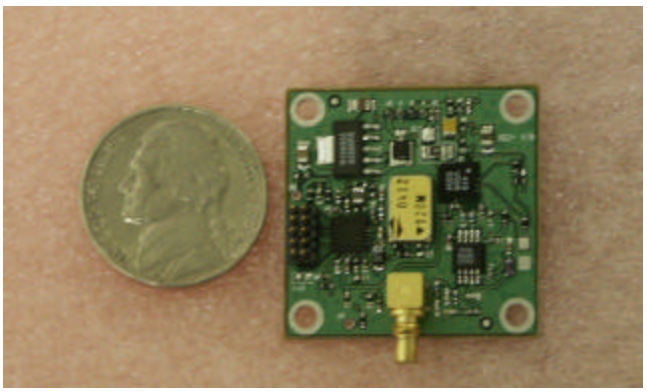

Figure 2: The MA06836 Telemetry Transmitter

PCM Encoder

The PCM Encoder for the TTS will be an in house (RTTC) design, whose foundation is the new MAX II series CPLD from Altera. The other major components of the encoder include a 16:1 Multiplexer (MUX), a 12 Bit Analog to Digital Converter (ADC), and a Pre-Modulation Filter (PFM). The encoder will be JTAG programmable and configured for the TTS as a 20 word RNRZ_L PCM frame at 10 bits (easily configured for 12 bit resolution) per word. Figure 3 presents a block diagram of the PCM Encoder.

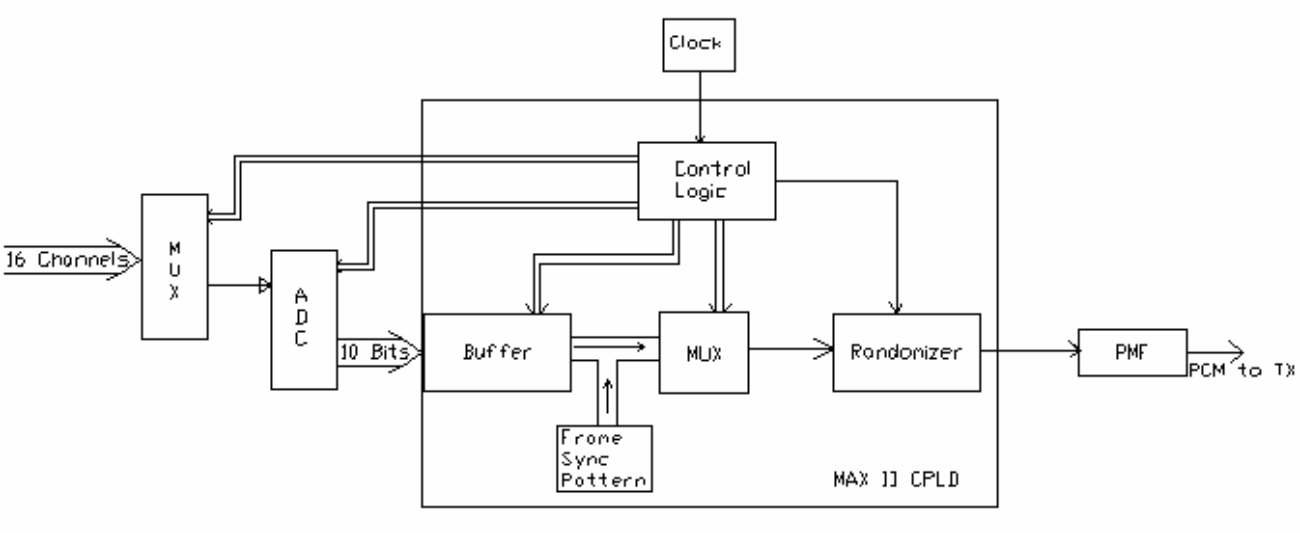

Figure 3: Encoder Block Diagram

The centerpiece of the design is the MAX II device. This CPLD promises lower power consumption, more logic elements, and half the cost of traditional CPLD's [2]. Due to the small space and environmental conditions that constrain the TTS, lower power consumption was the major factor in selecting this device. According to the Altera MAX II Power Calculator Spreadsheet the total power consumption of the device with this design is 43.4mW. As seen in Figure 3 the CPLD houses all of the logic control, address lines and enables, for the encoder as well as the internal multiplexer and 15 bit randomizer.

14 of the 16 inputs of the 16:1 Multiplexer are used for signals, 8 for the fuze data and 6 for housekeeping and/or spares. Channel 16 is grounded so that the multiplexer node may be shorted to ground between address changes. This helps to reduce any adjacent channel crosstalk [3]. The 12 bit ADC is clocked by the CPLD and all 12 bits are pipelined to the CPLD. However, for the TTS 12 bit resolution is not a necessity, so for ease of programming only the 10 most significant bits are used. A 6-Pole Bessel passive filter is implemented for the Pre-Modulation Filter. The filter output is amplitude adjustable and the cutoff frequency is set at 0.7*(Bit Rate).

The size of the encoder is dependant on the size of the components. The multiplexer is available in a 28 Pin SSOP, the Analog to Digital Converter is available in a 24 pin SOIC, and the CPLD is packaged in a 100 pin TQFP. The remaining components should fit splendidly onto the board size shown in Figure 4. All of the components are rated for industrial standards and should survive the harsh environments for SRP testing. However, environmental testing will be conducted on the TTS design to verify this.

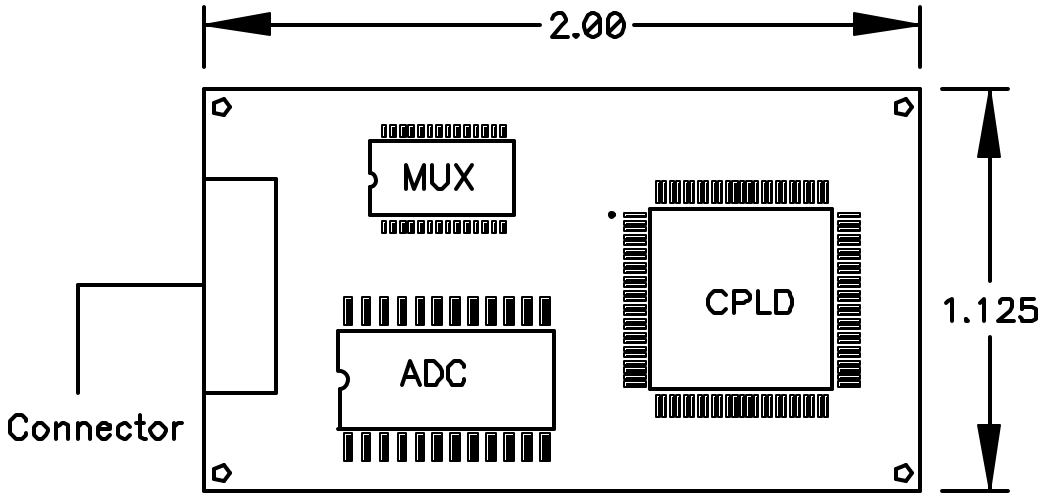

Figure 4: Encoder Board Size

Signal Conditioning Electronics

The MLRS Fuze has 8 signals that are to be monitored. Dependant on the fuze (standard or extended range) the signals vary in polarity. Due to the size constraints a 'one size fits all' approach will not work here. However, a card swap may be employed. The signal conditioning printed circuit cards will be identical with separate discrete component values. This will allow for a cost reduction as only one board will have to be spun. A simple jumper structure, employing 0805, 0 ohm resistors as jumpers, will allow the board to be populated for either the standard or extended range fuze. The gain resistors will have to be adjusted for each channel as will the capacitor values for the signal and anti-aliasing filters. The circuit topography for a single channel is shown in Figure 5.

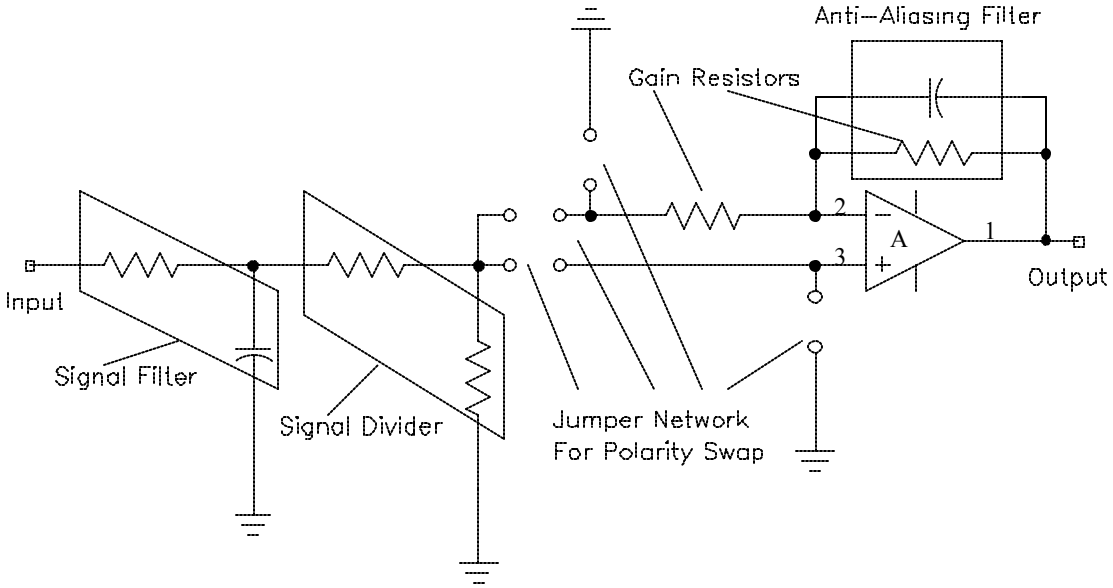

Figure 5: Signal Conditioner Topography

Battery

The first step in selecting a battery for a design is determining the voltage needed and the power consumption of the design. The TTS will be a 3.3 Volt system and Table 1 shows an estimated worst case power budget.

	Power Supply		Power
Part	Voltage	Current	Dissipated
PCM Encoder	3.3V	34mA	112.2mW
Signal Conditioning	3.3V	25mA	82.5mW
Transmitter	3.3V	450mA	1.485W
		total	1.68W

Table 1: TTS Power Budget

Energizer released a new **e²** line of Lithium batteries with rated operating temperatures of -40ºC to 60ºC. The AA variant is a 1.5 Volt, 2900mAH, battery that is able to deliver 1500mW of continuous power discharge for over an hour. Four batteries in series will produce 6 volts of power, which will allow enough over range for linear regulation as well as yield a longer time to cutoff. However, extensive battery testing will have to be implemented to prove this battery for flight. Current test plans include temperature soak and cycling, constant power discharge, and max discharge.

Antenna

In order to mount an antenna without physically altering the rocket, Haigh-Farr developed an antenna that mounts on the umbilical door of the rocket. This antenna, shown in Figure 6, has been successfully flown with previous MLRS telemetry packages and performed exceptionally. The umbilical doors are turned down and the patch antenna is bonded to the metal surface. Because the MLRS spins, the patch antenna essentially produces the same pattern as that of a traditional wrap antenna.

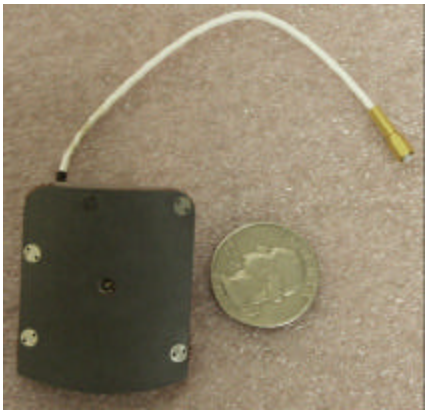

Figure 6: MLRS Patch Antenna

Conclusion

The electrical design for the TTS is near completion. Turning on the TTS on is the last piece to the electrical design. Because there is no way to mount an external line to the TTS in order to send relay commands, two ways to power up the system are being studied. One involves using the launcher umbilical signals to power up the TTS. The trouble with this approach is the small amount of time between the fuze signals being active and missile launch, as well as once the unit is on there is no way to turn it off. The second choice involves using a small RF receiver such as those used in keyless entries for automobiles. A programmed pattern can be transmitted to the TTS to turn the unit on and off. The disadvantage of this action is spectral inefficiency and powering the receiver chip.

The mechanical design is still underway. Designing a way to mount the TTS electronics inside the fuze cavity presents some interesting challenges, especially when trying to mount the TTS in such a way that it can be easily removed. Installation safety must also be considered as the TTS will be installed in a tactical rocket with a live fuze.

A Tactical Telemetry System for MLRS would aid the PFRMS Program Office in discovering any potential problems during SRP testing as well as help them diagnose any failures during the test. The TTS will be designed to accommodate both the standard and long range fuzes of MLRS and survive the harsh environments of stockpile reliability testing. The goal for the TTS is a package that fits in the fuze cavity of the MLRS rocket, is easy to install and uninstall, and deliver high-quality fuze data during flight.

Acknowledgements

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References

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