HIGH-G TELEMETRY SYSTEM FOR TANK MUNITIONS

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Abstract

The High-G Telemetry System for Tank Munitions was designed for and used on the Tank Projectile Course Correction Project, which is a program to design, develop, manufacture, assemble and deliver a course correction system, for a 120mm projectile by increasing the probability of hit against stationary and moving targets. The Precision Munitions Instrumentation Division (PMID) of U.S. Army TACOM-ARDEC has been providing high "G" telemetry services for over 50 years. Some of the capabilities of the group involve design, development, fabrication, testing, and data acquisition and analysis. The Precision Munitions Instrumentation Division is supporting this program by designing and manufacturing a telemetry system for monitoring on-board divert mechanism operation and sensors during the gun launch and in-flight.

The telemetry system that was designed for this effort was a six channel voltage controlled oscillator (VCO) FM/FM (frequency modulation) telemetry system. It was designed as a modular system that included a battery module, a multiplexer module, and a transmitter module. The system interfaced with a contractor's electronics modules through a set of 15-pin MDM connectors. The telemetry package was integrated into a 120mm tank round and fired at approximately 50Kg's. The telemeters were 100% successful in surviving the gun launch and collecting live flight data. Data transmitted by the telemeter included on-board sensor suite data, processor data, power levels, and others. The maximum frequency response of the system is 50 KHz, in order to transmit the processor's digital data.

Test Requirements and Objectives

The primary requirement/objective of the High-G Telemetry System was to successfully integrate the telemeter into a 120mm M830A1 tank round, survive the gun launch shock and acceleration of up to 75,000Gs, and transmit and capture the data with precision and

integrity. The data to be transmitted by the telemeter consisted of magnetometer data, solar sensor data, battery data, and a digital stream.

Test Assets

- 4 Microdyne RF Receivers
- 2 Honeywell Analog Tape Recorders
- 1 Digital Frequency Demultiplexer
- 1 Graphtec Arraycorder
- 1 Heim Digital Recorder

Telemetry System Overview

The design concept used for this telemetry system has been previously used and proven on numerous programs. The telemetry systems used in those projects was gun-hardened at 15,000 g's. The telemetry system used in the KE Course Correction Project is an ARDEC Model-ARRT-131 FM/FM analog system. One of the major benefits in our use of the traditional analog system over a digital system is the higher frequency response (up to 50 KHz) we can achieve for all 6 signals being captured. Another benefit of using an analog system is that the signal transmitted is a continuous signal, where all signal characteristics are preserved during the projectile operation and the raw signal can be analyzed either in real time or during post-evaluation procedures.

The ARRT-131 is a modular system. It consists of a battery module, a multiplexer module, and a transmitter module. The battery module contains fourteen 145mAh Kokam Lithium Polymer rechargeable batteries that provide approximately 290mAh of power at a nominal voltage of 25.9V and a maximum voltage of 29.4V. The batteries have been gun-hardened up to 75,000 G's. The multiplexer module is outfitted with 6 voltage controlled oscillators (VCO's), which have been used on numerous projects in the past and are also gun-hardened. The transmitter used for this project is an S-band transmitter, with a frequency of 2254.5MHz, a power rating of 250mW, and an IF bandwidth of 6MHz. This transmitter has been gun-hardened at 50,000 G's. All other electronic components used for this project have also been gun-qualified.

Each module of the telemeter was encapsulated using a two-part epoxy resin at ARDEC, where high-G encapsulation technique was pioneered. Encapsulation, although greatly improved, has been a standard practice in the field of telemetry since the 1960's. The modules were stacked and interconnected using 15-pin MDM connectors. The modularity of the ARRT-131 was a great asset to this project. It provided for easier assembly, manufacturing, testing and quality control and assurance. In this configuration a

damaged module could easily be identified, reworked and replaced, saving time and money in the process.

Prior to live fire testing, the ARRT-131 was fired in the airgun at Picatinny Arsenal, NJ where it successfully transmitted live data. The airgun test is part of an extensive functional testing that the telemeters experienced prior to the live fire testing.

The telemetry system was built in 2 different configurations (A, G) to accommodate the customer. The channel allocations for the two configurations are listed in **Table 1**. The system housings were slightly different and are also displayed.

The High-G Telemetry System was integrated into the projectile with an RF cable feeding through the projectile body and connecting to the S-Band Telemetry Patch Antenna located at the top of the projectile.

High-G Telemetry System

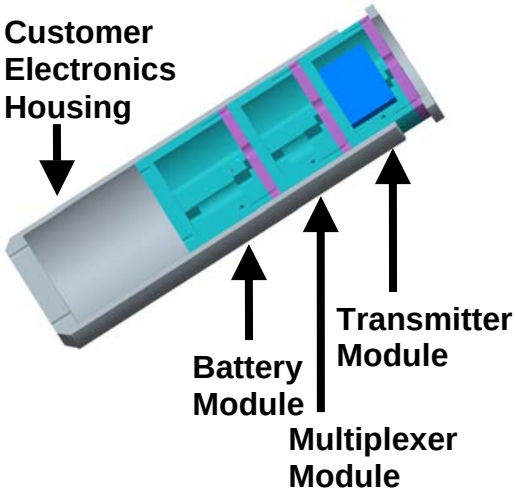
Battery Module

Multiplexer Module

Transmitter

High-G Telemetry System Configuration G after encapsulation

High-G Telemetry System Housing



High-G Telemetry System Housing

High-G Telemetry System Modules Configuration A

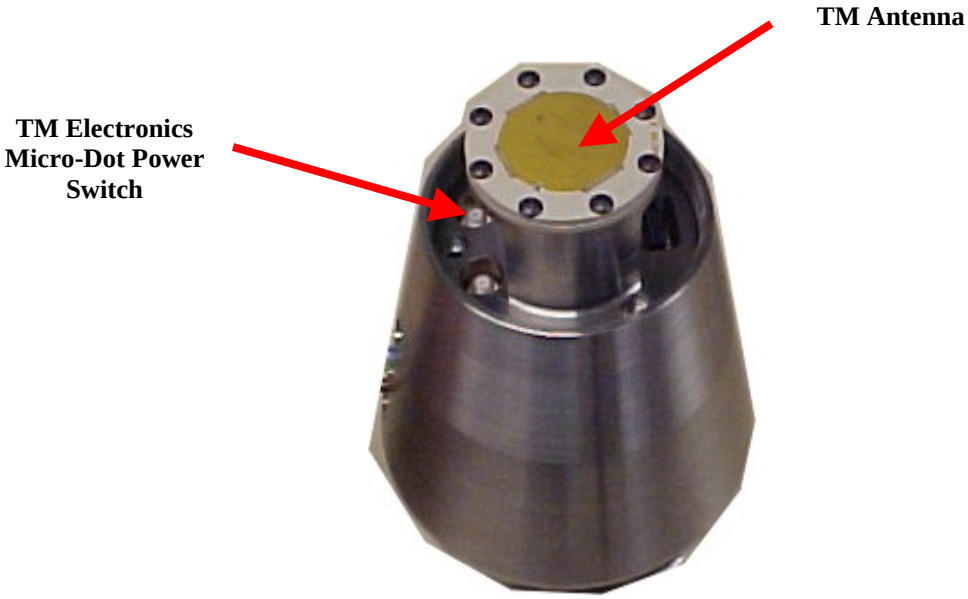


Table 1: Displays the 6 channels that are transmitted by the Telemetry System.

TM Channel	VCO Frequency	Freq. Deviation	Signal Description Config A/ Config G
1	1024 KHz	+/- 64 KHz	Digital Stream/ Digital Stream 1
2	768 KHz	+/- 64 KHz	Enable Signal/ Digital Stream 2
3	512 KHz	+/- 32 KHz	Solar Sensor/ Magnetometer 1
4	384 KHz	+/- 32 KHz	Magnetometer/ Magnetometer 2
5	256 KHz	+/- 32 KHz	Receiver Level/ Receiver Level
6	192 KHz	+/- 8 KHz	Telemeter Battery/ Telemetry Battery

Three Dimensional RF Link Analysis

Prior to firing the rounds a three-dimensional (3-D) link analysis was performed and the direction of a receiver antenna was determined for a receiver to get maximum signal strength in a telemetry situation where a receiver gathers information from a flying projectile. The carrier-to-noise ratio (CNR) of the link was obtained by calculating transmit and receive antenna gains caused by the difference angles between the bore sight and line-of-sight (LOS) and inserting them into a typical range equation when positions and angles of the projectile and receiver are given. For a fixed receive antenna, the angle was determined to maximize the average CNR over the interested range and for a tracking antenna, the angle at each position was selected to give maximum CNR or to direct the bore sight to the flying projectile with zero aspect angle. The results of the Link Analysis can be seen in **Figure 1**.

Live Firing Test

Twenty High-G Telemetry Systems were fired live at Yuma Proving Grounds (YPG) KOFA range. All twenty systems (100%) successfully transmitted live data. The data was recorded live using Analog Tape Recorders, a Heim Digital Recorder as well as a Graphtec Thermal Arraycorder digitizer at 500 kHz. The data was captured using 4 receivers in order to obtain the optimal signal. Samples of the captured data are shown in **Figures 2 and 3**. Spin data captured from the magnetometers on-board and the calculated spin using the AGC signals are shown in **Figure 4**. **Figure 5** shows the Receiver data, Fire Pulse and the IRIG Time data.

Figure 1: 3-D Link Analysis

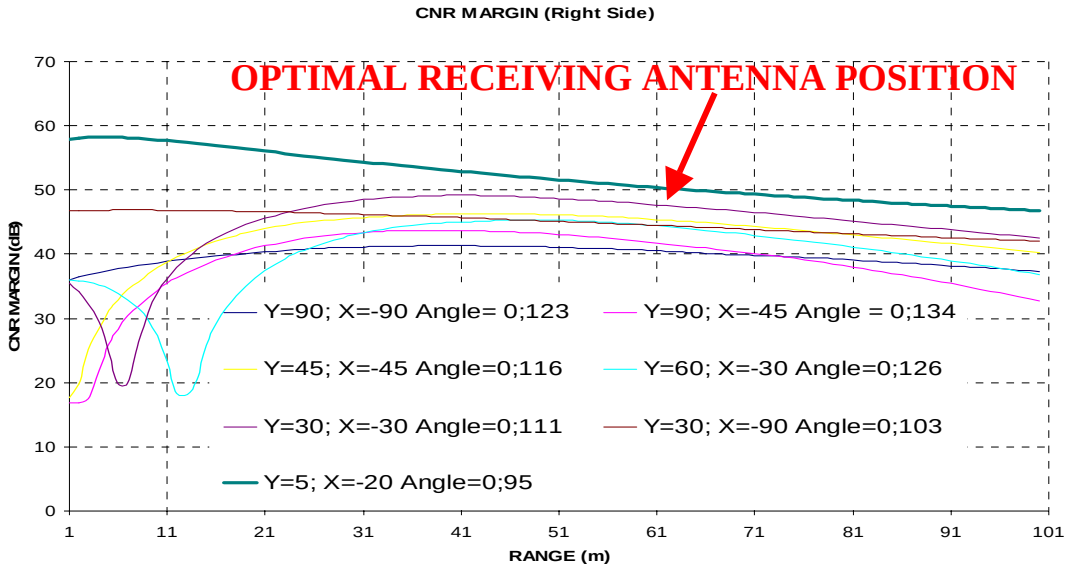


Figure 2: Live Data Configuration A

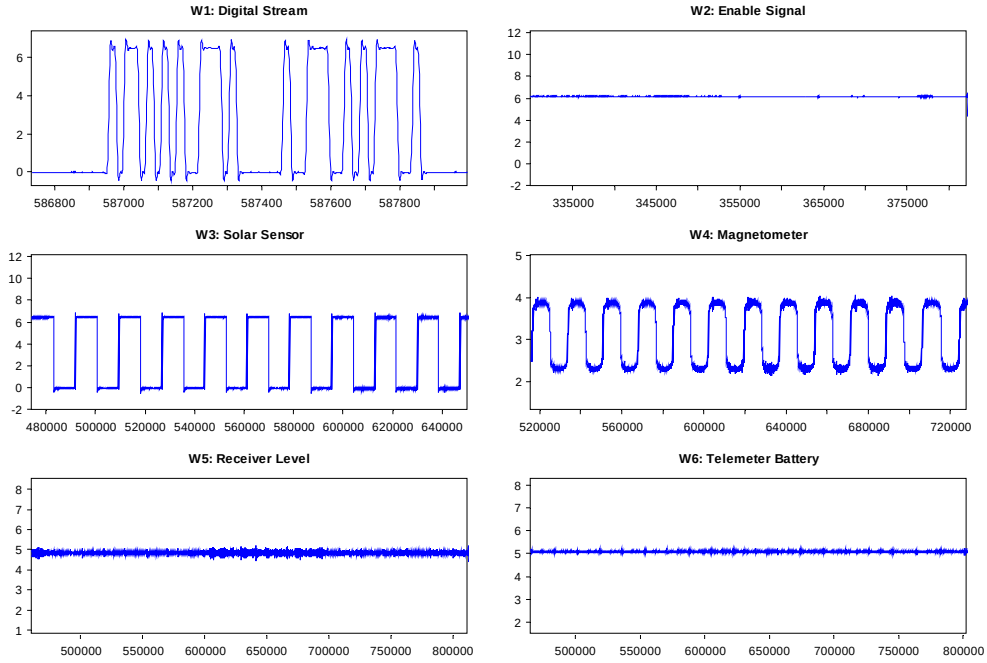


Figure 3: Live Data Configuration G

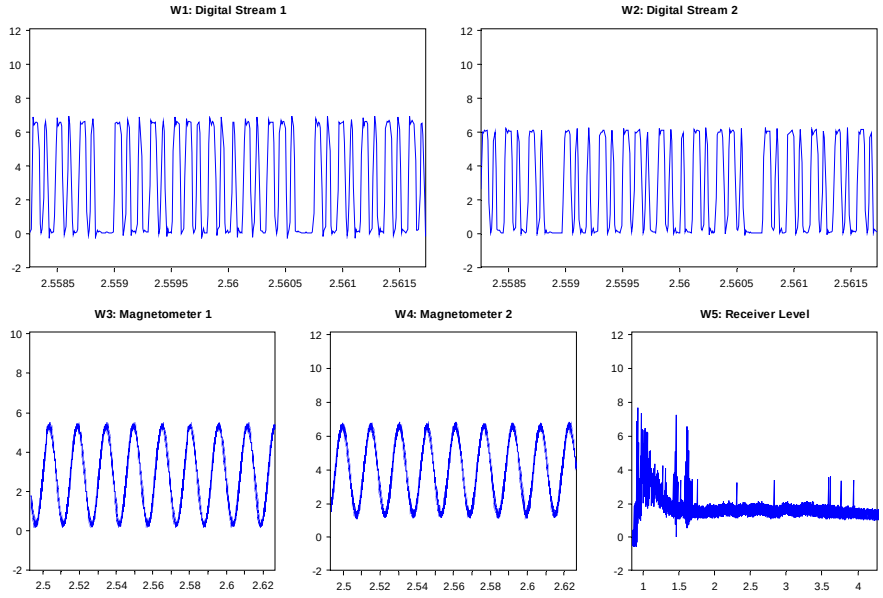
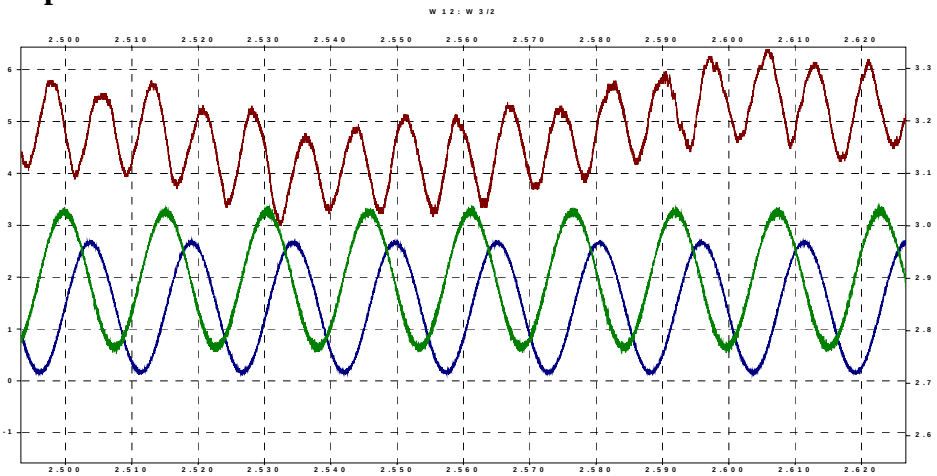


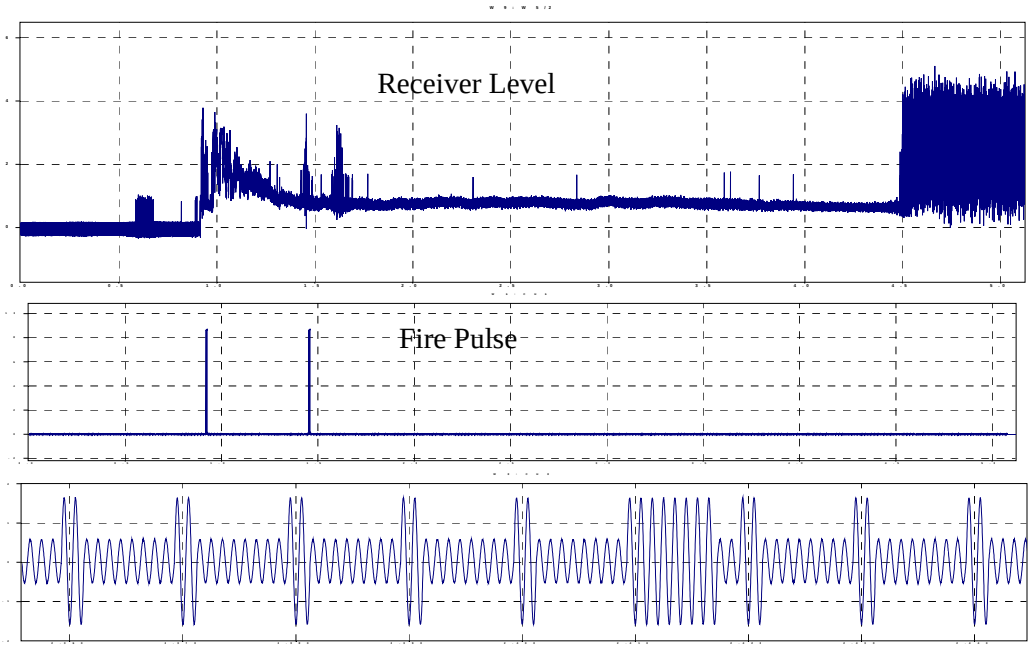
Figure 4: Spin data



Data fragment, system #1

Magnetometer, Axis 1
Magnetometer, Axis 2
AGC, TM Receiver

Figure 5: Receiver Signal Strength Data, Fire Pulse, and IRIG Time



Conclusion

ARDEC Precision Munitions Instrumentation Division (formerly: Telemetry Group) is a specialized division at Picatinny Arsenal, NJ that has been designing, developing, manufacturing and providing field support for telemetry systems for over 50 years. ARDEC pioneered High-G Telemetry systems in the early 1980's and has been producing reliable product and successfully capturing data ever since. The High-G Telemetry System is yet another example of the 50 years of experience and over 200 years of combined experience coming together to produce quality product.

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