# Subminiature Telemetry Systems For Submunitions

by

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## ABSTRACT

The increased sophistication and reduced size of the emerging generation of 'smart' submunitions has generated a requirement for subminiature telemetry systems for use in test and evaluation. The Army's SADARM and the Air Force's Sensor Fuzed Weapon (SFW) are typical of smart submunitions with multiple sensors, VHSIC signal processing, large warheads, and complex deployment sequences.

Reported here is the SADARM Telemetry Module, designed and developed by Honeywell to support the SADARM Program. The SADARM Telemetry Module applies MMIC and VLSI technology to provide sophisticated telemetry operation with a physically small, (2 $in^3$) package, in a harsh operating environment. The SADARM Telemetry Module senses 17 channels of digital and analog data, digitizes the analog data, multiplexes and PCM formats the data stream and transmits it via an IRIG compatible MMIC transmitter.

This SADARM Telemetry Module was used to collect in-flight performance data at the SADARM Congressional Tests in February, 1989.

Submunitions have evolved into very complex systems. Submunition development support testing has also become increasingly complicated. Onboard flight recorders are not feasible for live submunition tests because destruction of the submunition after the test precludes recovery of the recorded data. Telemetry provides the necessary test and measurement support required for efficient, cost effective, submunition development.

The application of conventional telemetry for this type of submunition instrumentation has also become more difficult as the submunitions have become

smaller in size and have more complex deployment sequences to evaluate. In addition, subminiature telemetry provides a practical, cost effective means to support field testing and development efforts in multiple munition weapon systems. In fact, subminiature telemetry offers the most practical instrumentation approach to evaluate the in-flight performance of several munitions dropped simultaneously.

The SADARM Telemetry Module, discussed in this paper, incorporated these subminiature telemetry performance requirements into a practical, cost effective instrumentation package for SADARM development support.

## SUBMINIATURE TELEMETRY

Subminiature telemetry modules such as the SADARM module discussed here are required to support submunition testing and development with effective low cost, onboard instrumentation. These subminiature telemetry systems are characterized by having:

1. Small telemetry module (TM) package size, with a volume $\leq$ 2 $in^3$
2. Miniature sensors located within the TM package, and integrated into the TM data measurement circuits.
3. High speed signal conditioning and data formatting circuitry designed to consume minimal DC power.
4. High performance Gallium Arsenide ( GaAs ) Monolithic Microwave Integrated Circuit ( MMIC ) transmitter.
5. Low profile conformal antennas to transmit the measured telemetry data to ground based telemetry receivers

## SMALL TM PACKAGE SIZE

The small TM package size results from the combined use of miniature integrated sensors, micropower CMOS technology used for the signal conditioning and data formatter circuits and GaAs MMIC integrated circuits used in the TM RF transmitter. Since the SADARM TM package size was so small, it could easily mounted within the SADARM submunition. Fitting the small TM package into the SADARM submunition was done with minimal impact to existing submunition electronics. It also added minimal mass, so the submunition flight characteristics were unaffected.

## INTEGRATED SENSORS

Subminiature telemetry systems require miniaturized sensors to perform the required telemetry measurements within a physically small volume. Ideally, these sensors are located within the TM package to form a small, rugged integral measurement unit. Honeywell has developed and built several different types of miniature integrated sensors such as accelerometers, thermal sensors and pressure sensors for use in a wide variety of applications.

At present, the SADARM TM uses external sensors to measure and evaluate performance. However if miniature sensors are required within the SADARM TM package at a later time, Honeywell will use those miniature sensors already developed and available for this subminiature telemetry application.

## SIGNAL CONDITIONING - DATA FORMATTER

In the SADARM TM, the 3 analog signals are conditioned, A/D converted and multiplexed using a Maxim 154 for the Data Aquisition integrated circuit. The multiplexed output from the Maxim 154 is then input to the Data Controller chip.

The SADARM TM uses an Altera Electrical Programmable Logic Device (EPLD) for the Data Controller. This EPLD can be conveniently reprogrammed with a desktop computer to provide required modifications to the Data Controller circuit operation and configuration. By using the EPLD, the SADARM TM Data Controller configuration remains flexible and can support changing telemetry word requirements quickly and at low cost.

The Data Controller takes the multiplexed output from the Maxim 154, the other 14 digital inputs, and formats all 17 of these signals into an IRIG compatible telemetry word. The Data Controller then delivers the telemetry word to the SADARM TM transmitter in a pulse coded modulation format.

Micropower CMOS integrated circuits are used in the signal conditioning and data formatter to provide these necessary TM data handling functions while consuming minimal DC power. The power saved with this approach is then available for the TM transmitter to provide and sustain a suitable transmitted RF output power level.

## TRANSMITTER

The MMIC transmitter consists of a dielectric stabilized, voltage controlled oscillator (VCO), followed by a high efficiency RF power amplifier transmitting the telemetry data with frequency shift keyed (FSK) modulation. Coarse tuning in the 2.2-2.3 GHz frequency band was performed by the dielectric resonator. The frequency modulation required for FSK is achieved by a voltage controlled reactance in the VCO feedback loop. The size of the VCO circuit is 1.73 x 0.25 mm. The size of the dielectric resonator ultimately precluded its use within the SADARM TM package so a microstrip resonator was substituted in its place.

To accommodate a wide range of telemetry antennas and operational conditions, the VCO is followed by a Class F power amplifier which is tolerant of output impedance mismatches. The power amplifier circuit measures 1.73 x 3.0 mm, and is designed to deliver 250 mW across the IRIG band with 70% power added efficiency.

To meet the antenna impedance mismatch requirements, two approaches were taken. The first approach was to design the amplifier as close to MESFET breakdown as possible (given fabrication tolerances) and power combine as many amplifiers as required for a given telemetry application through a passive combiner. The second approach was to increase the breakdown voltage by manipulating the drain-gate spacing of the final MESFET. The final result is a power amplifier which can deliver an RF signal to an antenna in 250 mW power increments and can tolerate large output impedance mismatches including short or open circuits.

## ANTENNA

The antenna used with the SADARM TM is a conformal, wrap-around, 6 - patch microstrip antenna array. This antenna is a rugged, low profile structure, capable of withstanding the harsh 10,000 g acceleration, launch environment. This array was designed and built by Honeywell for and provided a uniform toroidal radiation pattern about the SADARM submunition housing for clear consistent telemetry data reception on the ground. Subminiature telemetry antennas of this type can be built with repeatable performance at low cost by using standard printed circuitboard technology. These antennas reduced the overall cost of each SADARM subminiature telemetry system.

## CONCLUSION

This paper has discussed a field tested, SADARM subminiature telemetry module, and has discussed those technologies required to make this subminiature SADARM TM into a viable telemetry measurement instrument