MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

Author: Mr. Austin Mears
University of Texas at Arlington, United States, austin.mears@mavs.uta.edu

Mr. Jun Yao
University of Texas at Arlington, United States, jun.yao@mavs.uta.edu
Ms. Ya-Yu Monica Hew
Stanford University, United States, ymhew@stanford.edu
Ms. Erica Castillo
United States, erica.castillo@mavs.uta.edu
Mr. Fernando Leal
United States, fernando.leal89@gmail.com
Dr. Haiying Huang
University of Texas at Arlington, United States, huang@uta.edu
Dr. Ben Harris
University of Texas at Arlington, United States, pben@uta.edu

WIRELESS STRAIN SENSING SYSTEM FOR STRUCTURAL HEALTH MONITORING UNDER VARIOUS GRAVITY LEVELS

Abstract

In this paper, static and dynamic characterization of a batteryless wireless strain sensor tested under various gravity levels during NASA's Parabolic Flight Opportunity campaign will be presented. The intended application of the wireless strain sensor is for space Vehicle Health Monitoring Systems (VHMS). The ongoing demand of integrated space VHMS has been boosted by increasing global interests in space exploration, with NASA also highlighting the importance of space structural health monitoring in its Space Technology Roadmaps (STRs). By using a Wireless Strain Sensing System (WSSS), static and dynamic strain data can be acquired to evaluate the impact of acoustics and vibration on vehicles or equipment during launch/ground tests, to provide scalable monitoring of fatigue, and to detect structural failures at reasonable lowered costs.

The WSSS tested includes a wireless strain sensor consuming less than 10 mW, a solar energy harvesting unit, a frequency modulation/demodulation unit, and a Data Acquisition Unit (DAQ). Strain sensing is carried out using a conventional foil strain gauge. To wirelessly transmit the strain signal with a low power consumption, a voltage-controlled oscillator (VCO) is used to convert the direct-current (DC) strain signal to a high frequency oscillatory signal. This oscillatory signal is then transmitted by an unpowered wireless transponder by modulating the RF signal received by the sensor antenna. A generic solar panel with an energy harvesting circuit is used to power the strain sensor node. The wireless interrogator is equipped with a frequency counter implemented in a microcontroller to demodulate the strain sensing signal from the received antenna backscattering signal. The system features a power consumption that is a factor of ten times lower than current wireless strain sensors in the market, high data throughput, and remote solar powered. In this paper, the implementation of the WSSS and its subsequent payload will be discussed.

The NASA Parabolic Flight Opportunity program provided a space relevant environment for the WSSS. During the flights, the wireless strain sensing system, designed to monitor the structure deformation under external force application, was able to provide reliable strain measurements. Static test results

indicate that the WSSS is capable of keeping linearity and high sensitivity under various gravity levels. Dynamic test data show that gravity will not change the system's response to vibration. In addition, no RF interference was observed during the flights.

This paper hasn't been presented, with the exception of the flight test's final report to NASA's Flight Opportunity office.