Development of an instrument to measure density and moisture content of snow

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This paper presents design and development of a microcontroller-based instrument to measure snow moisture and density. This instrument makes use of λ/4 RF resonator for measuring complex dielectric coefficient of snow. Snow moisture and density were computed using empirical relations.

Keywords: Microcontroller-based instrument, Snow density, Snow moisture

Introduction

Knowledge of snow parameters is important for climatology, meteorology, hydrology, flood prevention and hydropower industry. Liquid water in a snow pack shows a dominant effect on reflection, absorption and transmission of electromagnetic waves especially in microwave region. Liquid water in snow plays a major role in metamorphism, mechanics and hydrology of snow, and in soil engineering. Conventional techniques to measures snow density and moisture are very complex and time consuming[1,2]. Complex dielectric constant of snow is a measure of its response to applied electromagnetic wave[3].

This study presents design and development by CSIO Chandigarh, in association with SASE, a DRDO laboratory, of a microcontroller-based instrument to measure snow moisture and density.

Proposed Instrument

Complete system consists of (Fig. 1): i) snow moisture sensor unit; ii) microcontroller based main unit; iii) handheld keypad cum display unit; and iv) power supply unit. Technical specifications of instrument are: resonant frequency measurement range (resolution, 1 MHz), 500-950 MHz; dielectric constant $\in'$ measurement range (real part), 1-3.0; dielectric

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constant $\in''$ measurement range (imaginary part), 0-0.15; liquid water content measurement range (wetness), 0-15% volumetric; snow density measurement range, 0-0.6 g/cm^3; data logger storage, 4 MB NVRAM; operating temperature range, –20°C to +50°C; power supply (6.5 Ah sealed lead acid battery), 12 V; data transmission, RS-232; communication parameters, 115200 bps, 8 bit data, 1 stop bit, no parity, no handshaking; sensor spikes length, 75 mm; and sensor spikes separation, 20 mm.

Snow Moisture Sensor Unit

Sensor is a fork shaped quarter wavelength microwave resonator (resonant at the frequency with length of resonant structure = ¼ of wavelength). It is open circuited at one end and short-circuited at another end. It resonates in air around 900 MHz. Prongs (made up of stainless steel) are thin enough with sharpen ends for easy and deformation less insertion into snow. Distance between two prongs is about 20 mm. Radio frequency power is fed in and out of the structure through coaxial cables and coupling loops. Handle of this unit houses RF electronics. RF Sweep generator[4-6] comprises of voltage controlled oscillator POS-1000W and RF power leveler circuitry. RF power leveler limits feeding RF signal level to 0±0.5 dBm throughout the sweeping range. It works under the control of processing card and sweeps (frequency range, 450-1000 MHz) to determine resonance frequency and other electrical parameters of sensor. Processor card under