Low Earth Orbit Satellite Transceivers for Communication with Mobile Stations

Introduction

Natural disasters such as hurricanes, wild fires, and floods are deadly, but information gathered through mobile sensory equipment can help direct aid and save lives. Viable mobile sensory equipment requires communication systems that are reliable under any condition, cost effective, and light weight. Mobile satellite transceivers can transmit and receive signals anywhere on earth if there is a clear line of sight to the sky, they are relatively inexpensive, and they are compact and lightweight. This paper is a review of LEO satellite transceivers used for communication with mobile stations.

Commercial Applications of Satellite Transceivers

Satellite transceivers are designed to work with a specific network of LEO satellites which utilize the same communication protocols [1]. Individual transceivers can be purchased directly from manufacturers for users designing new systems, but most transceivers are built into more complex products such as satellite phones, portable wireless hotspots, or tracking and monitoring equipment. Honeywell produces the SAT-401 (>$589) which can send bursts of data up to 170 bits, and receive bursts of data up to 800 bits [2]. The frequency range of this transceiver, which is called the S-Band, is typically used for voice and limited data services to mobile stations, and exists between 1.5 and 1.7 GHz [2]. The SAT-401 is typically used for tracking cargo, vehicles, and other valuable assets [2].

Iridium Satellite LLC produces three satellite transceivers; Iridium 9602 ($223), Iridium 9602 ($182), and Iridium Core 9523 ($1257) [3], [4], [5]. All three modules function at the same frequency near the lower end of the S-Band (1.5 – 1.7 GHz) [3], [4], [5]. The less expensive 9602 and 9603 modules can send Short Burst Data messages up to 340 bytes and receive messages up to 270 bytes [3], [4]. The 9602 measures 41x45x13 mm and weighs 30 g, significantly larger than the 9603, which measures 31.5x29.6x8.1 mm and weighs 11.4 g [3], [4]. The Core 9523 module can send Short Burst Data messages up to 1960 bytes and receive messages up to 1890 bytes, as well as handle voice and data services, but it is the largest of the three measuring 70.44x36.04x14.6 mm and weighing 32 g [5]. These transceivers are utilized by companies to produce communication and tracking devices, by official research groups to monitor remote systems, and by hobbyists for personal projects.

Technology of Satellite Transceivers

Frequency Allocation and Communication Protocols

Wireless frequency bands are allocated to prevent interference. The preferred range for Satellite communications is 3 to 10 GHz, because attenuation due to atmospheric conditions is lowest at those frequencies [1]. Mobile transceivers typically operate in the L-Band (1.5 to 1.7 GHz), or the S-Band (2.0-

2.7 GHz) [6]. The data rate of a transceiver is a function of the frequency band, the modulation scheme, and the code used [6]. Many satellites use simple modulation schemes such as pure phase shift keying, in which the phase of a sinusoid represents a discrete state, because they reduce receiver complexity and power consumption [1]. For example, Iridium satellites utilize quadrature phase shift keying, which is discussed in [6] [7]. Since propagation delay in satellite communication is too long to acknowledge messages, and the long distances lead to low SNR, coding decreases the error rate by adding redundant bits to messages which can be used to find and even fix errors in the signal [1]. Without these protocols to modulate and encode signals, wireless satellite communication would be impossible.

Hardware Specifications

Transceiver designs vary in complexity, but all modern transceivers share several hardware characteristics. Two antennas are used, one is a transmitter and the other is a receiver. When receiving a message, the transceiver will alternatively use analog filters and low noise amplifiers as described in [8] to clean the signal before demodulating the analog signal and sending the signal through a high precision analog to digital converter [8]. To send a message, an encoded digital signal is input to the transceiver where it is modulated and amplified before being sent to the transmitting antenna [8]. Transceiver designs also reduce noise by eliminating mutual capacitances and impedances through proper shielding, ground planes, and other methods [8].

Implementation of Satellite Transceivers

A system of satellites, permanent ground stations, and ground networks are required to make use of mobile satellite transceivers [1]. Signals sent from mobile transceivers to satellites are relayed to permanent receivers and through local networks back to the user [1]. Signals from the user follow the same path back to the satellite before being sent to a mobile transceiver. Like a mobile phone plan, a satellite transceiver will not be able to connect to a satellite unless they pay for the bandwidth being used. Iridium's basic plan costs $15.99 monthly plus $1.09 per kb of data and $0.05 to check for incoming messages [9].

The transceiver itself relies on antennas and amplifiers to receive a usable signal from the satellite due to attenuation over distances of 160-500 km for low Earth orbit satellites and 10,000 to 20,000 km for medium Earth orbit satellites [1]. Rock Seven sells control boards for the Iridium 9602 and 9603 transceivers, which both cost $250 including the transceivers, that provide hardware for power management, antennas, and connections for interfacing directly with controllers through USB [10], [11]. A Digital Signal Processing unit is needed to demodulate the incoming signal and modulate the outgoing signal. The transceiver is only a small part of a working satellite communication system, but it provides the necessary link between the satellite and the ground station.

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