IPSTAR Ground System Design Enables Consumer/SME Satellite Broadband

An Efficient Channel Coding Case Study

The Shin Satellite IPSTAR satellite broadband system was an ambitious and complex project from its beginnings in 1997. In those early days of the satellite broadband industry, there were many projects chasing the same goal of global broadband to the masses.

IPSTAR emerged from among many failed satellite broadband system plans to become a success through innovative engineering ideas and solid business planning. The key concept was to deploy massive frequency re-use similar to that used in mobile cellular networks, combined with advanced coding technology.

To achieve that goal, Shin carefully selected a team of technology partners. Partners who could implement the ground-breaking satellite design, launch the world's biggest commercial payload, develop new gateway and network management technology, and engineer subscriber terminals for advanced performance and low cost design.

Shin Sat's selection to design and develop the ground system, including an innovative air interface, Satellite Hub Station modems, and a subscriber terminal reference design was Efficient Channel Coding Inc. (ECC). The resulting ECC design takes advantage of IPSTAR's high-performance spot beams and includes the first commercial deployment of efficient Adaptive Coding and Modulation on the outbound and inbound links. Using the ECC reference terminal design, along with a digital IPSTAR ASIC from ECC, IPSTAR can create competitive pricing for its satellite service by cutting the cost of satellite air time and licensing multiple manufacturers to produce terminals.

Designing the Ground System

IPSTAR first sought out ECC because of its expertise in forward error correction (FEC) techniques, knowing that the technology is valuable for increasing power and spectrum efficiency in satellite systems. The ECC brand of FEC, called Turbo Product Codes (TPCs), is based on an efficient decoding algorithm that enabled the world's first practical turbo code error correction chips and software in late 1998.

But ECC pushed beyond its known TPC technology to propose a full ground system design for IPSTAR.

"We said 'let us build it'," said Mark Vanderaar, president of ECC. "They wondered if we might be too small, but they let us get started and show them what we could do. I think we've proven that it was a good decision for both of us."

Thanks to the willingness of Shin Sat to listen to new ideas and concepts, the operator granted a number of small contracts to ECC that enabled it to prove its engineering approach. Beginning with a prototype terminal, the ECC designs impressed IPSTAR to the point where initial production contracts were granted.

All along the way, the ECC team coordinated its efforts with that of the satellite designers, Shin Sat and Loral Space Systems, to maximize the potential of the complete, integrated IPSTAR broadband system.

A Next Generation Ground System for IPSTAR

Entrusting ECC with the leading role in the ground system design resulted in an advanced satellite ground system that includes several major breakthroughs for IPSTAR:

- Dynamic, optimized assignment of resources to individual subscriber terminals for significantly improved use of satellite resources
- A low-cost terminal reference design that includes the ECC2100 ASIC chip
- Equally efficient gateway modems integrating the ECC technology
- Two way high-speed internet services via satellite, at speeds of 10 Mbps and 4 Mbps to and from the user respectively
- The ability to license terminal production to local manufacturers in the Asia Pacific region where IPSTAR operates.

On-board TCP/IP acceleration and in integrated XML database make IPSTAR broadband easy to install and use for a number of IP-based applications as well:

- Virtual Private Network (VPN)
- Video On Demand (VOD)
- Voice Over IP (VoIP)
- Multicast data, video or audio

The ECC2100 implements advanced digital satellite modem functions that include the processing of variable modulation and advanced forward error correction formats “on-the-fly” without loss of data due to resynchronization. The chip also enables a dramatic cost reduction in the bill of materials for IPSTAR terminals, resulting in price points that are attractive to consumers and small business. In 2006, ECC shipped over 100,000 ECC2100 ASICs.

The Patented Dynamic Link Assignment (DLA) System

Satellite systems normally use QPSK modulation with concatenated Convolutional and Reed-Solomon error correction codes. In addition, the RF links typically use fixed margins with the size of the margin dependent upon the maximum rain attenuation predicted for the service area.

The IPSTAR ground system manages each user terminal separately, with each using the maximum level of modulation in combination with as high a code rate as the instantaneous link conditions will allow. Using Dynamic Link Assignment (DLA), developed in coordination with Codespace and Shin Sat, as link conditions fade, the modulation level and code rate is changed to maintain BER requirements. Since only a low percentage of user terminals in a beam will encounter significant rain attenuation at any time, this technique significantly increases average information throughput per unit bandwidth.

Testing by ECC used a comparison of dynamic links versus links configured to match specifications for a typical Digital Video Broadcasting (DVB) system. User terminals were located in Singapore and Tampa, Florida. The amount of rain attenuation for 99.5% annual availability was determined by using the new ITU-R rain attenuation model.

The maximum bits per symbol per Hz achievable with the present design is 3.52 using 16-ary modulation with a 0.879 rate TPC. When a particular terminal encounters rain or other degradation (link attenuation, interference, spot beam roll off, etc.), its modulation level and code rate is reduced. The minimum bits per symbol per Hz that can be used for the system is 0.65 using QPSK with a 0.325 rate TPC. Each user's data is time multiplexed onto a forward link channel. Since channels within a band have a fixed frequency and time relationship, a user terminal can change modulation and coding rapidly without resynchronization.

DLA also provides a significant advantage for spot beam systems. In the typical spotbeam system the satellite antenna gain from edge of coverage to beam center varies by 4 dB. As a result, the satellite EIRP varies by the same amount over the beam coverage. Dynamic links, as opposed to fixed links, allow each user terminal to automatically sense its location in the spot beam and then operate at the highest modulation and code rate possible, significantly increasing the transponder data throughput.

In addition to the subscriber terminal, ECC supplies the companion Satellite Hub Station Modem Equipment to the iPSTAR system. The hub equipment includes the Hub Station Transmitter, called the TOLL Transmitter and the Hub Station Receiver, called the STAR Receiver. The TOLL Transmitter provides the advanced, adaptive, wideband waveform required to support thousands of broadband satellite terminals. The STAR Receiver is a burst-mode demodulator that can simultaneously process multiple frequency channels and time slots in a single 1U unit. Combined, these units offer an unbeatable cost and space effective system for iPSTAR.

Together, the system mitigates rain fade and significantly increase the number of subscribers per transponder compare to fixed links with QPSK and Reed Solomon/Convolutional concatenated codes. This increase is from one and one half to four times depending on the RF frequency and the rain attenuation region.

IPSTAR System Wins Industry Innovator Award

The innovative IPSTAR design was awarded the "2006 Industry Innovator for Technology Development and Application" in the private sector by the Society of Satellite Professionals International (SSPI) on the opening night of the Satellite 2006 conference.

IPSTAR now reports 70,000 terminals in operation with 10 gateways serving 14 countries. And, despite the diverse regulatory environment of the multi-nation Asia

Pacific, the rollout continues. Three new gateways are complete and licensed with 10 Gbps of capacity waiting to serve the people of China.

Contact Us For Your System

IPSTAR is just one example of what we do for our customers. We can help you in the same way. Please contact….