Development of DSP Satellite Communications

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Originally, I was a microwave engineer specializing in every kind of microwave devices development. However, last half of NTT Labs and at Mitsubishi Electric, I worked for satellite communications systems development. After 1997, in the university, I have been striving to develop principles of the DSP communications satellites systems design.

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Why DSP ?

In 1996, I heard that whole transponders of ICO consist of DSP. It was amazing that channeling, inter-beam connection and multiple beam BFN (beam forming network) were completely made by DSP. Since I was a systems engineer responsible for communications payload design, I immediately bought a book titled as “Digital Signal Processing in Communication Systems” by Marvin E. Frerking at Scholar’s Book Store in El Segundo, LA. When I bought this book, owner of the book store said to me that you bought a good book which was read by many engineers in this area. Surely, this was a good book which was very difficult to understand. This book and E. Oran Brigham’s “The Fast Fourier Transform” greatly helped my learning DSP as a late starter. Only by DSP, multiple beam active array and inter beam switching can be made, which are indispensable to large capacity mobile satellite systems.

What was the best means to make a large number of cell?

Mobile satellite systems lost much funds and human resources invested in low earth orbit systems. In mobile satellite communications, requirement for mobile terminal is determined by diameter of the cell, not by distance to the satellite. It is necessary to cover whole service area by a large number of small cells. What was the best means to make a large number of cells? By systems cost, it was apparent that GEO was the best. In the future, satellite should provide large number of small diameter cells, increasing number of customers and decreasing size of the earth terminals. These future systems will be made possible by DSP.

Multiple beam DSP satellite (’03~’05)

In these 3 years, by support of the government fund, I am investigating supporting technologies for the DSP satellites. Figure 1 shows concept of multiple beam DSP satellite.

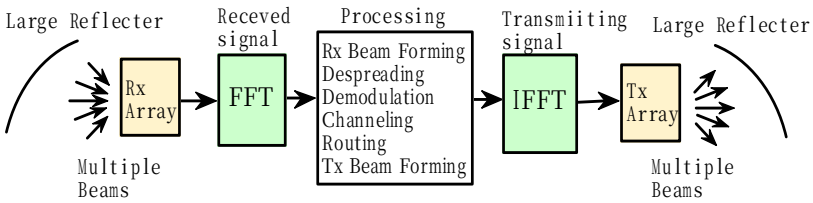

Fig.1 Concept of multiple beam DSP satellite.

Received signal was transformed to frequency samples by FFT. Array beam forming, channelization, dispreading, demodulation and routing are carried out by frequency samples. We are investigating design principles for these systems.

CDMA Despreading by DSP

In many mobile satellite systems, CDMA uplink is used. In this case, onboard despreading is necessary before channelization and routing. In order to simplify despreading, we are investigating simple method which is possible using DSP. Figure 2 shows a new despreading configuration which was made possible by using DSP.

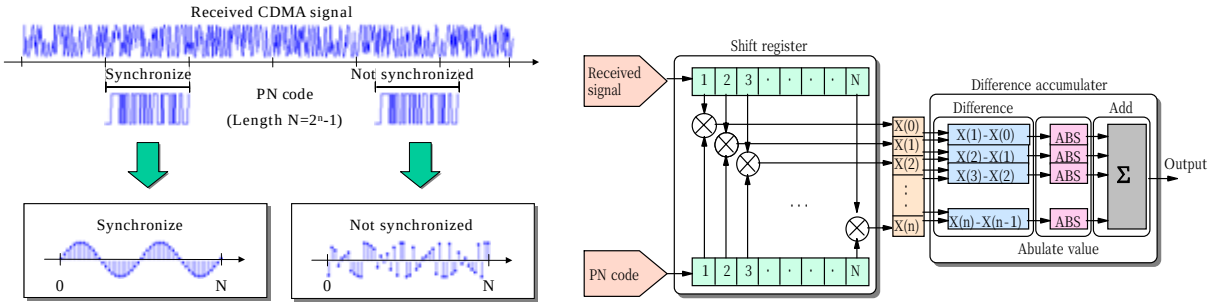

Fig.2 Despreading CDMA signals by DSP

Pipeline FFT to handle wide receive band

It is necessary to increase processing speed of FFT if handling of more than 100MHz bandwidth is necessary. By applying pipeline FFT to disperse FFT calculation to several DSP hard ware, it become possible to increase speed of FFT. Figure 3 shows proposed pipeline FFT configuration using DSP hardware. This kind of technology will be indispensable to DSP satellites.

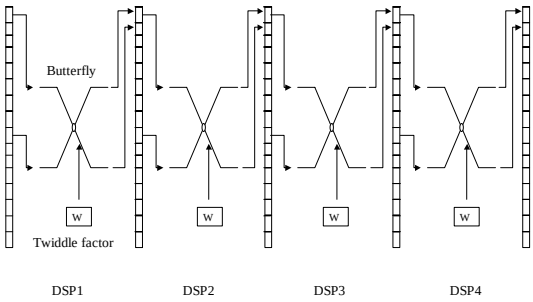

Fig.3 Pipeline FFT by DSP

Demodulation of PSK from frequency samples

In the configuration shown in Fig.1, onboard processing is performed using frequency samples. In this context, we developed BPSK and QPSK demodulation method starting from frequency samples.

Application of low bit rate PSK reception

In the past, in satellite communications, low bit rate PSK signal, lower than several kbps, was difficult to demodulate due to existence of phase noise. However, using PSK demodulation method based on

frequency samples, it is possible to demodulate low bit rate PSK signal with phase noise. Satellite communications by extremely low bit rate PSK signal enables possible use of low antenna gain terminals. Figure 4 shows concept of Ku or C-band system using omni directional terminals.

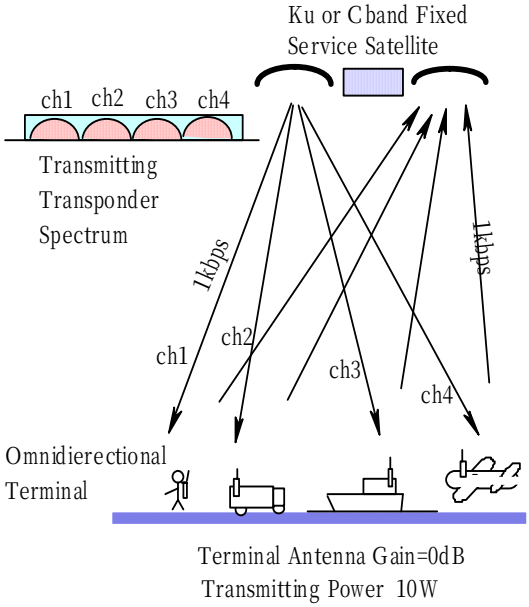

Fig.4 Concept of Ku-or C-band system using low bit rate terminals.

Broadcast reception using frequency samples

We are investigating processing system based on frequency samples. The concept can be applied to broadcasting band. In case of AM or FM broadcast reception, If whole broadcasting band were transformed to frequency samples, all existing channels can be found and demodulated simultaneously.

We also successfully developed AM and FM demodulation method based on frequency samples. Last year we cooperated for development of this method with Texas Instrument Labs in Tsukuba Japan.

Members of my Lab. at the graduation ceremony on March 24 2005.