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CHANNEL SIMULATOR UPGRADE TO USE FIELD PROPAGATION DATA

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Abstract--The JPL Channel Simulator lab has been modified to allow full duplex links and to allow the use of field propagation data for link fading. This capability will be used to test equipment for the joint AUSSAT/NASA mobile satellite experiment in July, 1989.

## 1. Introduction

The JPL Channel Simulator was built by the Mobile Satellite Experiment (MSAT-X) program to facilitate the end-to-end testing of components of a mobile satellite link. The simulator was designed to simulate a one-way link with interfering sources, gaussian noise, and fading. Recently, modifications were made to allow a full-duplex link to operate with field propagation data. This paper will describe the channel simulator, discuss the changes made and the rationale for them, and describe the capabilities of the simulator.

## 2. The Channel Simulator

The channel simulator has been described before (Davarian, 1987); we will only discuss the features that have been upgraded. Figure 1 provides a simplified block diagram of the channel simulator. The simulator has four transmitters whose output levels are independently set and then summed together. This allows a desired channel, a co-channel interferer, and two adjacent channel interferers. Each channel can independently undergo fading. Gaussian noise can be added to the combined channels. The desired channel is then selected by the receiver.

The Rician fading is accomplished by splitting the signal equally into two paths, the Line-Of-Sight (LOS) path and the Rayleigh faded path. The Rayleigh fading is accomplished by complex modulating the inphase (I) and quadrature (Q) components of the input signal by a complex simulated Rayleigh signal. The faded signal is then attenuated and combined with the LOS signal to create the Rician faded signal. The Rician K factor, defined as the ratio of the LOS power to the Rayleigh power, is set by step attenuators.

To use the channel simulator, the MSAT-X terminal processor and TCM/8DPSK modem are used. The terminal processor provides PN data at 4800 bps to the modem, which modulates the data. The modem provides an I channel and a Q channel to the transmitter. The receiver provides a 28.8 KHz IF signal to the modem for demodulation. The detected bits are then sent to the terminal processor for error detection. Operating in this one-way mode allowed the characterization of the modem under fading conditions.

### 3. The Upgrades

In July, 1989, the MSAT-X Propagation Measurement Van (PMV) will be conducting experiments with AUSSAT in Australia using the Japanese ETS-V satellite. A joint experiment with the National Communications Systems (NCS) was proposed. This experiment involves using secure telephones (STU III's) over the MSAT link. To accomplish this requires an adapter designed and built by Electrospace, Inc. (ESI) and a JPL built MSAT-to-ESI interface board. Due to the fact that the ESI equipment was not designed to work with the MSAT system, it was necessary to test the complete system before traveling to Australia. Also, to ensure that the Australian propagation environment would allow the establishment of secure communication, it was required that the system be tested under conditions present in Australia. To accomplish this required two changes to the channel simulator.

First, to test the full system required the ability to do full duplex communications. A second receiver was constructed to allow the return link to be detected. The desired channel transmitter was used for the forward link and the co-channel transmitter, offset from the forward link by 100 KHz, was used for the return link.

Second, to test under Australian conditions required Australian propagation data and the ability to use it. The propagation data was supplied by Dr. Wolfhard Vogel, of the University of Texas (Vogel, 1989). This data was in the form of fade amplitudes from the nominal value; this data was sampled at 500 samples/second. The Rayleigh fader was modified to use this data.

To use the field data fading, the LOS signal is turned off. Instead of complex modulating the signal with the Rayleigh data, the signal is modulated with I and Q data generated from the field propagation data (Figure 2). An IBM PC/AT with a Data Translation DT2828 dual channel Digital-to-Analog board was used to generate the data. The DT2828 provides a -10 to 10 volt capability; the nominal output value was set at 7 volts. All fades were done from the nominal value, with the I and Q channels being faded by the same value.

### 4. The Testing

Figure 3 provides a block diagram of the test configuration for the NCS testing. After verifying the channel simulator full duplex link, both with and without field data fading, the full secure link was tested. Due to time constraints and initial problems with the various interfaces to the MSAT equipment, only one propagation data file was used, number 394. Figure 4 provides a plot of the amplitude fades versus time for this file. The goal of the test was to achieve a secure link and maintain it with the field data fading and an  $E_b/N_0$ , due to gaussian noise, of 11 dB. This goal was achieved.

### 5. Conclusion

The channel simulator is now capable of supporting a full duplex link, using any propagation data to recreate the conditions a system will encounter. This allows us to go into the field with the confidence that the NCS test will succeed in Australia. Also, any improvements in MSAT equipment that are made after the AUSSAT experiment can be tested under actual field conditions. This

capability of the JPL Channel Simulator will allow measurements made by propagation experimenters to be directly used in designing and testing equipment for the MSAT system.

## 6. Acknowledgements

The author would like to thank Joe Sumida and Jeff Packard, of JPL, for their help in modifying the channel simulator. The NCS testing could not have been completed without Dr. Wolfhard Vogel providing his propagation data. Also, the contributions of the following individuals for their assistance in the NCS testing are acknowledged: Craig Cheetham, Richard Emerson, Thomas Jedrey, Norman Lay, Leon Truong, and Arvydas Vaisnys of JPL; Scott Phillips of Electrospace, Inc.; and Fred Lawler of Telos Aerospace.

## References

Davarian, F., "Channel Simulation to Facilitate Mobile-Satellite Communications Research," IEEE Transactions on Communications, Vol. COM-35, No. 1, pp. 47-56. January 1987.

Vogel, Wolfhard J., Personal Communication, April 18, 1989.

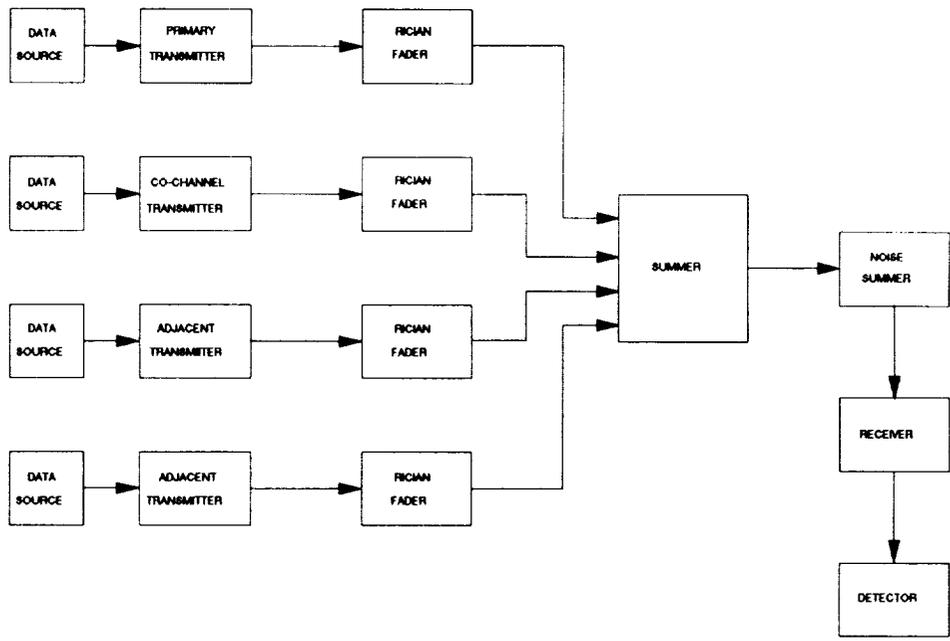


Figure 1  
Channel Simulator Block Diagram

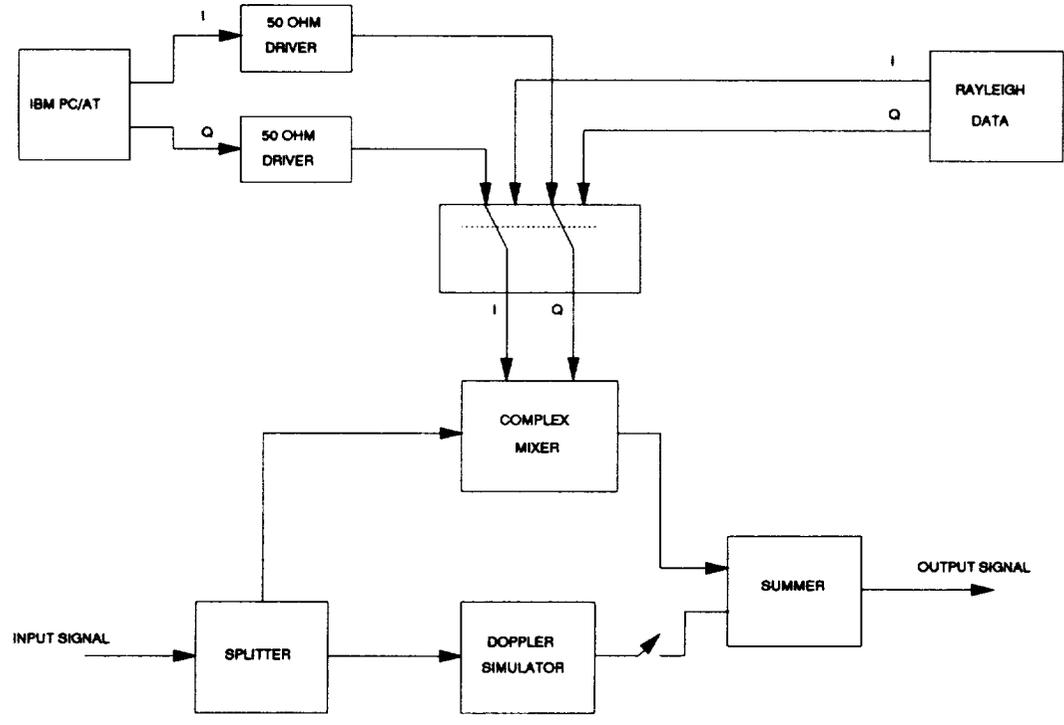


Figure 2  
Fader Using Field Propagation Data

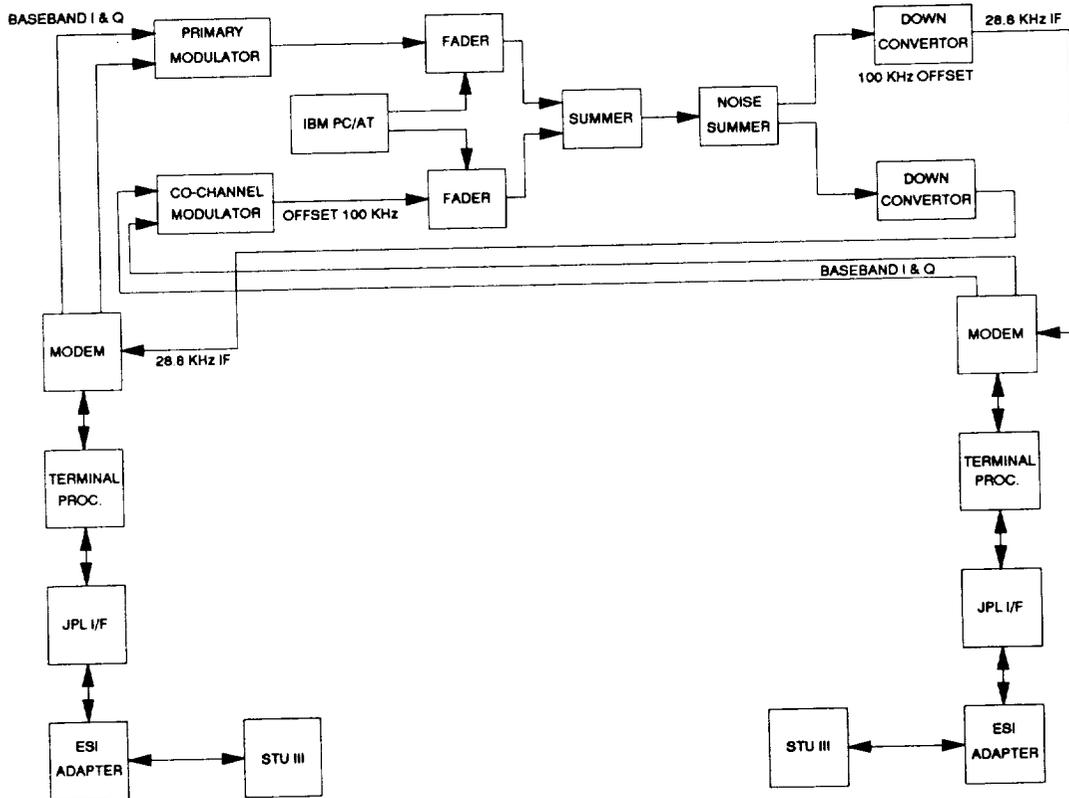


Figure 3  
NCS Testing Configuration

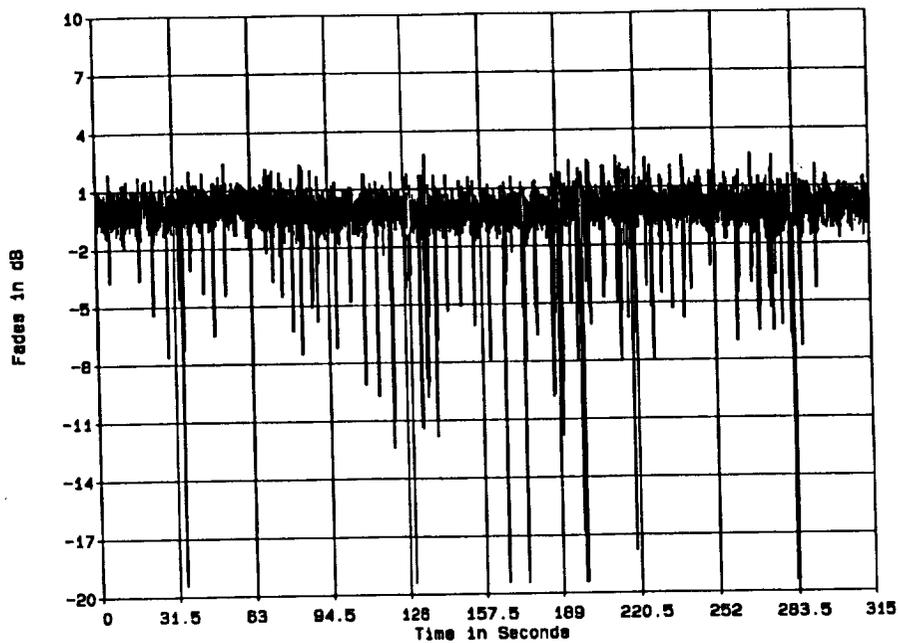


Figure 4  
Amplitude Fading Versus Time