Applications of a Telemetry Signal Simulator

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ABSTRACT

This paper will discuss the use of a specialized telemetry signal simulator for pre-mission verification of a telemetry receiving system. This will include how to configure tests that will determine system performance under "real time" conditions such as multipath fading and Doppler shifting. The paper will analyze a telemetry receiving system and define tests for each part of the system. This will include tests for verification of the antenna system. Also included, will be tests for verification of the receiver/combiner system. The paper will further discuss how adding PCM simulation capabilities to the signal simulator will allow testing of frame synchronizers and decomutation equipment.

KEYWORDS

Simulation, Signal Generator, Doppler Shift, Multi-path Fading

INTRODUCTION

In the past, providing a simulation device with these capabilities would have required several pieces of test equipment and significant man hours to configure the system for testing. This paper will describe the design and applications of a simulation system that includes capabilities that allow the user to simulate Doppler shift, dynamic fades and PCM data streams. The simulator provides high output power to allow use as a boresite transmitter to test the entire receive system. Also, it provides complete remote control to allow the user to automate pre-mission testing. The simulator provides multiple modulation modes and a large tuning range that meets or exceeds all requirements of today's telemetry systems. Finally, the paper will provide application examples for simulation configurations that ensure proper operations of the receive telemetry system.

DESIGN CONSIDERATIONS

A signal simulator was designed to meet the requirements for complete telemetry simulation. The simulator employs a combination of digital and RF design techniques to provide the simulation capabilities needed for telemetry receive systems. A review of the block diagram, Appendix 1, will highlight the various features required for system simulation.

The Digital Waveform Generator serves as the digital modulation source. It is a high speed discrete digital system clocked at 150 MHZ. By using a digital source, the simulator can easily support multiple modulation formats such as AM, FM and PM. By adding a limited amount of RAM, it can also provide PCM simulation and support PCM/FM & BPSK applications. In addition, a pseudo-random number generator has been included which provides compatibility with industry standard Bit Error Rate Test Sets. The Digital Waveform Generator also includes a Modulated Numerically Controlled Oscillator (MNCO) which allows the simulator to provide small tuning increments, less than 1 Hz, and further serves as a device to provide Doppler shift simulation. A block diagram of the Digital Waveform Generator is included as Figure 1.

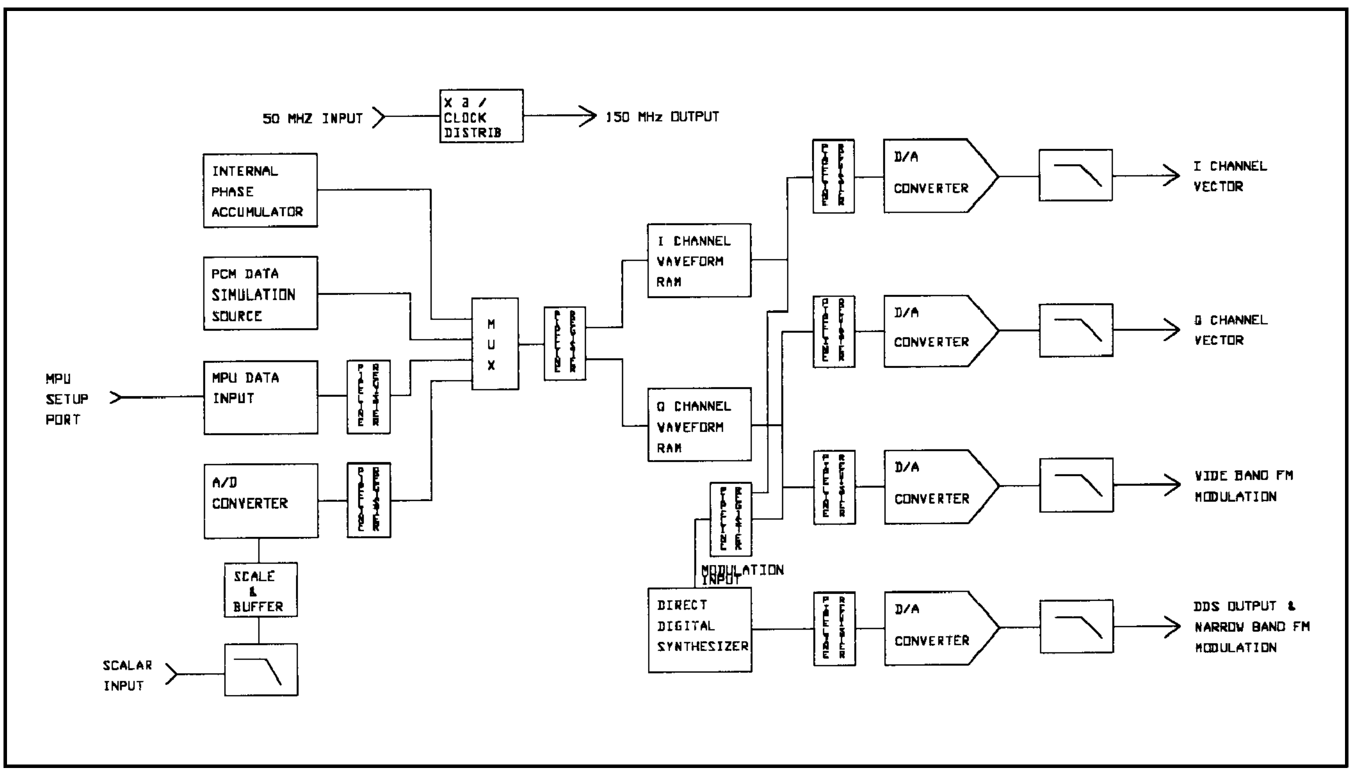

Figure 1 - Block Diagram For Digital Waveform Generator

The modulator is a vector modulator. This approach was used because it is easily configured for multiple modulation formats. This design also allows the simulator to perform wideband data simulation with data rates up to 20 Mbits. The simulator also provides external inputs to support custom user modulation formats; including PAM/FM, FM/FM subcarriers, SGLS subcarriers and IRIG tones for command destruct.

The simulator RF path is based on a three synthesizer conversion process. This allows the simulator to provide a wide range of output frequencies. Currently the design provides RF tuning from 10 MHZ to 600 MHZ and from 1400 MHZ to 2500 MHZ. This allows the simulator to cover the standard telemetry bands, such as P, L & S bands. It also allows it to cover the command destruct bands. Furthermore, because it provides RF outputs as low as 10 MHZ, it can be used as an IF source. Finally because all of the local oscillators are synthesized, the simulator can provide sweep capabilities.

Fade simulation is accomplished by the Automatic Level Control (ALC) circuitry. It contains dynamic attenuators that are controlled by digitally generated analog fading signals. By generating the fading control signals digitally, the fade depth, rate and phase can be accurately controlled reducing the need for additional external equipment. The simulator includes a power splitter and ALC circuitry to produce two RF outputs. This allows the simulator to test receiver/combiner systems.

The two RF output channels are then routed through high power RF amplifiers and digitally controlled attenuators. This allows the RF output power to be varied from -130 to +20 dBm. This will allow the simulator to be used for boresite applications.

All of the features, of the simulator, are remote controllable using IEEE-488, RS-232 and RS-422 interfaces. Because the simulator allows complete remote control of all configuration parameters, the user has the capability to create highly sophisticated simulation scenarios that will verify complete system performance.

RECEIVER/COMBINER TESTING APPLICATION

Perhaps the most common uses for the simulator can be found by looking at the Range Commanders Council's Test Methods for Telemetry Systems and Subsystems. The simulator can provide most of the RF generation requirements for tests outlined in this document. In addition, this simulator will eliminate the need for some additional test equipment required by this document. Figure 2 shows the simulator configured to perform receiver/combiner testing.

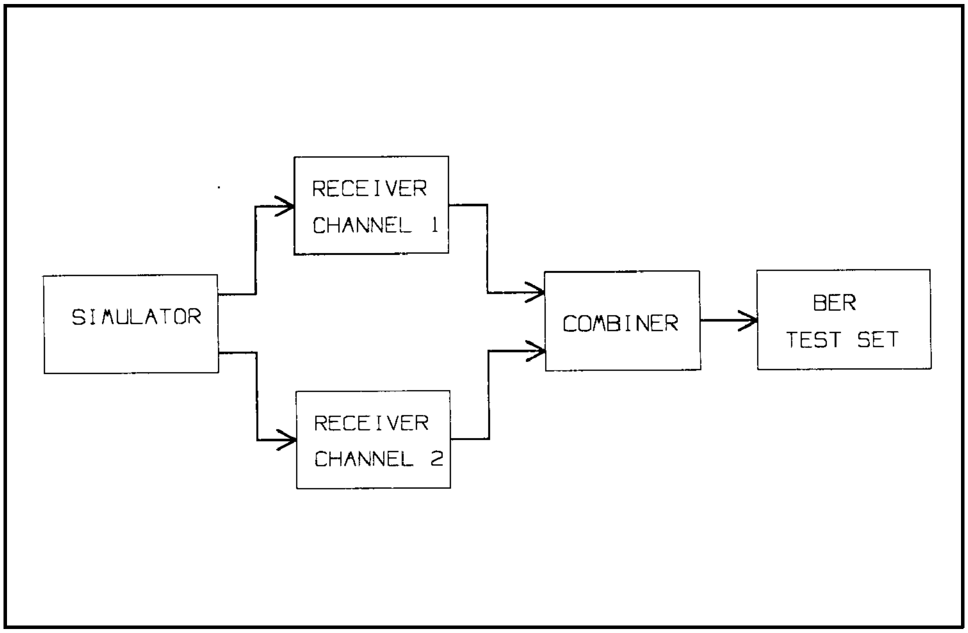

Figure 2 - Receiver/Combiner Test Configuration

In this case the simulator provides all of the signal requirements to dynamically test the combiner system. Without the simulator, the user would have to provide an external power splitter and fade simulator, along with associated equipment, to calibrate them. By including them in the simulator, testing errors due to improper test setup will be reduced.

BORESITE TESTING APPLICATION

The system simulation equipment can be greatly reduced when using the simulator as a boresite transmitter. Because the simulator has an internal pseudo-random number generator and a PCM data simulator, the user can now perform bit error rate (BER) testing through the complete downlink without the expense of an additional BER test set at the boresite location. Additionally, the +20 dBm output power allows the simulator to be used as a boresite transmitter without the need for an additional RF amplifier. The capability to perform these tests throughout the complete receive system allows the user to verify operation of the complete receive system while keeping simulation cost to a minimum. A boresite system also allows tracking antenna calibration, the ability to perform boresite "snap on" tests and perform optical camera alignment.

DYNAMIC VEHICLE SIMULATION APPLICATION

The simulator's fade and Doppler shift simulation capabilities provide the user with the devices to fully simulate dynamic vehicles. The Doppler shift parameters are programmable, allowing the user to specify the Doppler shift range and the rate of change. This will simulate the frequency shift experienced by a moving vehicle. The simulator can also be made to dynamically fade the RF output levels. By specifying the fade depth, rate and phase, the user can simulate any degradation of signal experienced from multipath fading, vehicle maneuvering and dropouts caused by flame attenuation. These functions allow the system to be tested from the optimum conditions to the worst conditions.

COMPLETE RECEIVE SYSTEM SIMULATION APPLICATION

By using a simulator, combined with current computer technology, a complete system test configuration can be created. Figure 3 shows a complete receive system configuration that will provide all the simulation functions required to verify operation of the receive system.

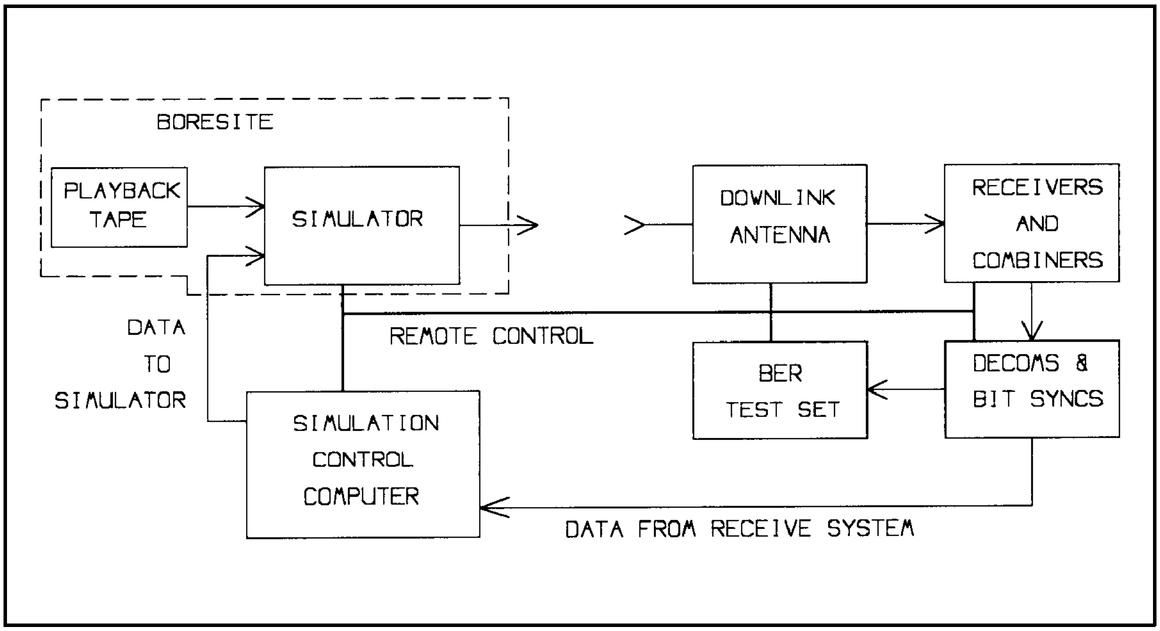

Figure 3 - Block Diagram Of Simulation System

In this scenario, a computer could control the equipment and perform various simulation exercises. It could configure the simulator to output a pseudo-random bit pattern and then obtain the BER results from the BER test set at the receive site. The computer could download data into the simulator via remote control and then monitor the receive data. Comparisons of the downloaded data versus the received data would indicate system performance. Finally, for overall testing of mission data a playback of previous mission data could be externally routed to the simulator and this could be transmitted from the boresite location.

CONCLUSION

The Microdyne TSS-2000 provides all the simulation capabilities necessary to provide pre-mission verification of the receive system. The multi-modulation and multi-frequency capabilities, combined with the Doppler shift, fade simulation and PCM simulation allows the user to test the receive system under the best conditions and the worst conditions. These features combined with the high output, power allows the simulator to be used for complete simulation, including boresite testing of the entire RF downlink.

REFERENCES

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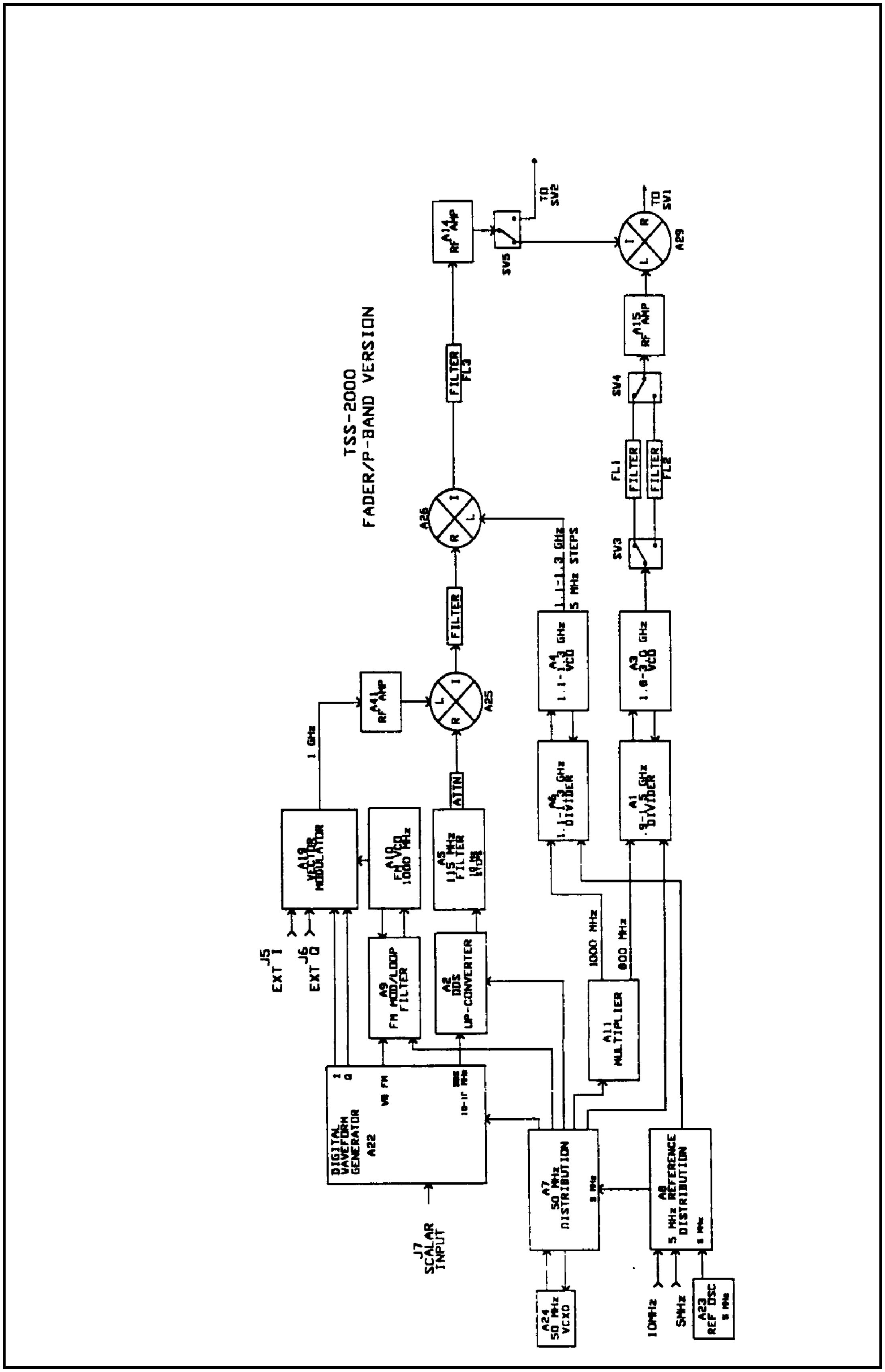
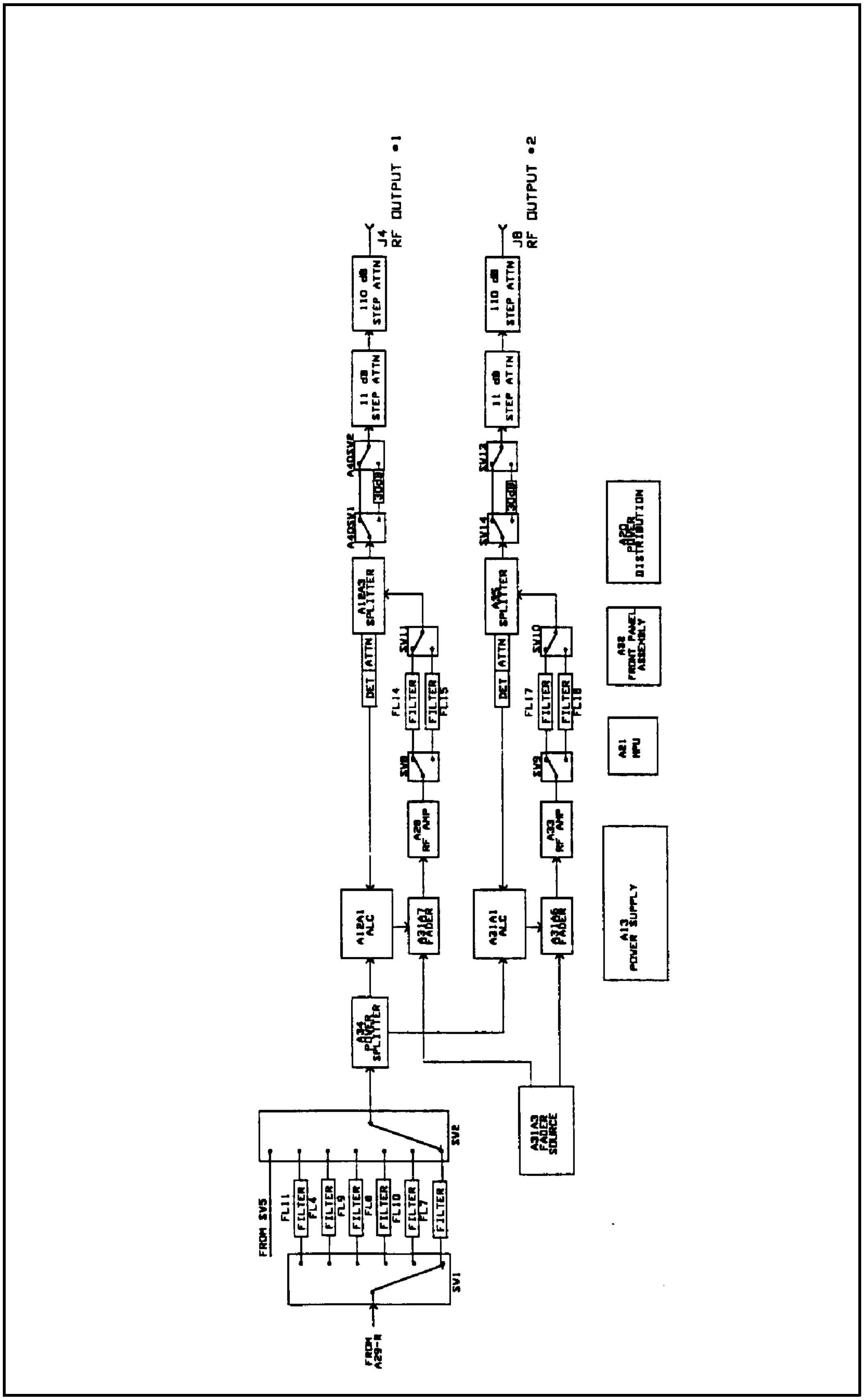


Appendix 1 TSS-2000 Block Diagram sheet 1 of 2



Appendix 1 (cont) TSS-2000 Block Diagram sheet 2 of 2