THE SERENDIP II DESIGN

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ABSTRACT. Serendip II is an automated system designed to perform a real time search for narrow band radio signals in the spectra of sources in a regularly scheduled, non-Seti, astronomical observing program. Because we expect Serendip II to run continuously without requiring dedicated observing time, we hope to survey a large portion of the sky at high sensitivity and low cost. Serendip II will compute the power spectrum using a 65,536 channel fast Fourier transform processor with a real time bandwidth of 128 KHz and 2 Hz per channel resolution. After searching for peaks in a 100 KHz portion of the radio telescope's IF band, Serendip II will move to the next 100 KHz portion using a programmable frequency synthesizer; when the whole IF band has been scanned, the process will start again. Unidentified peaks in the power spectra are candidates for further study and their celestial coordinates will be recorded along with the time and power, IF and RF frequency, and bandwidth of the peak.

INTRODUCTION TO PIGGYBACK SETI

The piggyback approach to Seti is an attempt to maximize the ratio of volume of parameter space searched to cost. It analyzes the signal received at the telescope in the course of the non-Seti radio astronomy program and searches for narrow band signals. The analysis is done in real time and the system can be fully automated, allowing an unattended round-the-clock search. The great virtue of this approach is that it requires no dedicated telescope time. While the selection of telescope direction according to non-Seti criteria means that the parameter space will be filled in a rather haphazard manner, this is not necessarily disadvantageous. Cogent arguments have been advanced for both nearby solar type stars and distant galaxies as optimal Seti samples. At this early stage we haven't enough information to select very much more judiciously than the unbiased sample of the parameter space this random "sampler" will provide.

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 421–424.

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SERENDIP I

Project Serendip (also an acronym: Search for Extraterrestrial Emission from Nearby Developed Intelligent Populations) was initiated at the University of California's Hat Creek Radio Observatory in 1980, and operated at the Deep Space Network at Goldstone in 1981 and 1982. The original data acquisition system employed a 100 channel spectrum analyzer with a resolution of 1000 Hz per channel and an integration time of 30 seconds. A 20 MHz band of the IF spectrum was scanned over a period of 100 minutes. The power spectrum was calculated using an analog autocorrelator and microprocessor, and then searched for a spectral peak with an amplitude exceeding a preset threshold; if such a peak were found the power spectrum and time would be recorded. Subsequent application of cluster analysis techniques to the space of time, peak frequency and power, right ascension, declination, hour angle, azimuth, and elevation would reveal multiple observations of a single source and give insight into the nature of terrestrial interference, making it possible to reject a later detection of the same source.

SERENDIP II

Serendip II employs the same search strategy as Serendip I but will achieve a radical improvement in sensitivity by upgrading from 100 channels of 1000 Hz each to 65,536 channels of 2 Hz each. The 2 Hz/bin resolution was chosen so that Doppler drifts due to the earth's motion would not smear a narrow band signal in a ten second integration time.

The new acquisition system (Figure 1) is based on an Intel 80286 multibus microcomputer with 512 Kbytes of memory, floppy and Winchester disks, and a Mercury ZIP3216 multibus array processor which performs a 65,536 point complex fast Fourier transform (FFT) in 472 mS. The front end consists of a quadrature mixer system with a programmable frequency synthesizer (local oscillator) controlled by the microcomputer.

The IF signal from the radio telescope is first split into quadrature components and then converted to baseband by two mixers. The two signals then pass through seven pole eliptic low pass filters for anti-aliasing and are sampled by two eight bit analog to digital converters. The samples are stored in an input buffer which is part of the array processor's memory. After 1/2 second, 65,536 complex samples have been stored, which are then used to compute a 65,536 point power spectrum using a 16 bit block floating point FFT algorithm. While the FFT is being computed, the new signal is being digitized and stored in the buffer memory for the next FFT. The array processor sums 20 power spectra together to improve the signal to noise ratio before transferring the integrated power spectrum to the microcomputer, which performs a baseline subtraction and searches for peaks above a 6 sigma

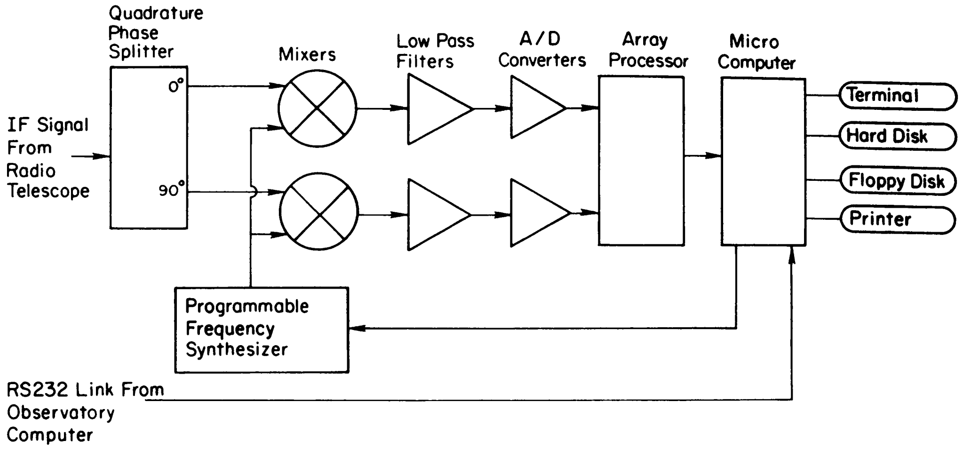

Figure 1. Serendip II

threshold. The power, frequency, and bandwidth of such peaks are recorded along with the time and telescope direction, which come from the observatory computer over an RS232 link. Every ten seconds (20 power spectra), the microcomputer increments the frequency synthesizer by 100 KHz, so the 30 MHz IF band is covered in 50 minutes.

Serendip II will have the further capability of responding to detections by rejecting signals which coincide with known sources of interference, as well as identifying and rejecting local interference by searching for repeated detections in a given channel when the local oscillator is changed or the telescope moves to a new object. We may also program the instrument to look for broader band signals using 4 Hz, 8 Hz, 16 Hz,... 1024 Hz pseudo-bins by adding adjacent signals together. We can add more CPU boards to the system, which would allow us to use more sophisticated post processing algorithms, such as detection of pulses or signals drifting in frequency. The Mercury array processor currently has 640 Kbytes of fast local memory, but this can be expanded to 16 Mbytes, thereby allowing us to perform one million point transforms using 32 bit block floating point arithmetic.

We hope to operate Serendip II at the Arecibo telescope. The sensitivity of Serendip II at Arecibo is given by:

$$s = \frac{n_\sigma T}{S} \sqrt{b/t} = 1.5 \cdot 10^{-25}\ \mathrm{W/m^2} \qquad (1)$$

where n_σ is the detection threshold value we use to select peaks (6 sigma), T is the system temperature (45° K), S is the system gain (8°/Jansky with one polarization), b is the bandwidth per channel (2 Hz) and t is the integration time (10 sec). The detection threshold is chosen so that we record an average of one detection every two days from gaussian noise.

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REFERENCES

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