The Electric Field Experiment for HELIOS (E 5b)

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Experiment 5 b is designed to measure electric fields in the frequency range of 0 to 200 kHz with high frequency resolution. It comprises three tunable plasma wave receivers, a fixed tuned (wide band) receiver, and a waveform sampler. These components are describes in details and block diagrams are presented. Finally the experiment operations and individual commands are discussed.

Experiment 5 b hat die Aufgabe, elektrische Felder im Raum im Frequenzbereich von 0 bis 200 kHz mit hoher Auflösungsgenauigkeit zu registrieren. Es umfaßt drei einstellbare Plasmawellen-Empfänger, einen festen Breitband-Empfänger und ein Registriergerät für die Wellenform. Diese Komponenten werden im einzelnen beschrieben und in Form von Blockdiagrammen dargestellt. Abschließend werden die einzelnen Betriebs-Kommandos für das Experiment diskutiert.

1. SURVEY

The purpose of Experiment 5b is to measure electric fields in the frequency range 0 to 200 kHz with high frequency resolution and so the experiment is designed to complement experiment 5a, which has high time resolution.
Experiment 5 b consists of three tunable plasma wave receivers, a fixed tuned (wide band) receiver, and a waveform sampler, for measurement of electric field strength n the frequency range 1 hz to 200 kHz. A block diagram of the experiment is shown in FIG. 1. Of the tunable receivers, the high frequency receiver tunes to 96 different frequencies, separated by about 4 %, the mid frequency receiver to 48 frequencies separated by about 8 % and the low frequency receiver to 24 with 15 % separation. The wide band receiver covers approximately the same band as the low frequency receiver and is not tuned but the bandwidth varies with the handling mode. The data from these receivers are called science data. Only science data are telemetered in formats 1, 2 and 3. The output of the waveform sampler is called shock data. It is used only in format 5 which contains mixed science and shock data, and format 6 which is pure shock data.

2. EXPERIMENT DESCRIPTION

2.1 Tunable Receivers

The three tunable receivers are all of the same type and their block diagrams are shown in FIG. 2. They are basically two stage Wein bridge filters (tuned amplifiers in FIG. 2), tuned by switching the resistors and capacitors in the feedback network which determines the center frequency. The tuned amplifiers and filters are preceded by an input attenuator with 4 positions, and an input amplifier, which amplifies the signal to a level which is above the noise of the tuned amplifiers. The input attenuators are automatic, that is, if the signal rises above a predetermined level at any of several points in the circuit, then the attenuator is immediately set to a higher attenuation position.
The gain of a single stage of a Wein bridge filter at a frequency ω is:

$$T(\omega) = \frac{T_o}{1 + i\,Q\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)}$$

and we use 2 such stages for an overall transmission of:

$$|T(\omega)|^2 = \frac{T_o^2}{1 + Q^2\left(\frac{\omega}{\omega_o} - \frac{\omega_o}{\omega}\right)^2}$$

The equivalent power bandwidth of such an amplifier is:

$$\Delta\omega = \int_o^\infty \frac{|T(\omega)|^2}{T_o^2}\,d\omega = \frac{\pi\,\omega_o}{4Q}$$

(bandwidth of ideal filter transmitting same noise power).

In the low and mid frequency receivers, the two stages are essentially identical. In the high frequency receiver, however, Q's of the two stages are different because, owing to its narrow bandwidth, we had too much difficulty making the two filter stages tune to the same frequency. When two

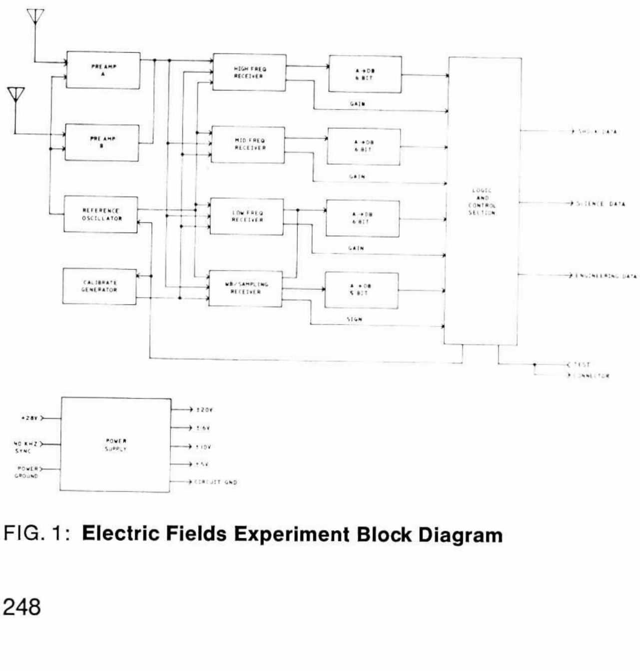

FIG. 1: **Electric Fields Experiment Block Diagram**

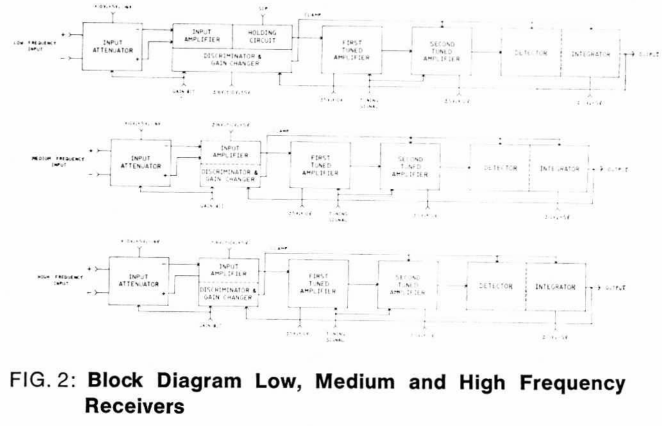

FIG. 2: **Block Diagram Low, Medium and High Frequency Receivers**

TABLE I: **RECEIVER PARAMETERS**

Receiver	HF	MF	LF	WB
No. of frequencies	96	48	24	1
Highest Frequency	205 khz	6.07 khz	309 hz	~ 200 hz
Lowest Frequency	6.4 khz	208 hz	11 hz	1 hz
Typical Q	20	12	5	—
Threshold sensitivity (sine wave input)	2 μV	1 μV	2 μV	30 μV rms

stages have different values of Q, the equivalent power bandwidth is given by

$$\Delta\omega = \frac{\pi\,\omega_o}{2\,(Q_1 + Q_2)}$$

TABLE I shows the pertinent parameters for each of the receivers.

When a receiver filter is first tuned to a given frequency, the output takes a certain length of time to come up to equilibrium. This time is of the order of $(\Delta\omega)^{-1}$. For the low frequency receiver, this time works out to be of the order of one satellite spin period so that the low frequency receiver cannot sense variations in the signal as the satellite turns. In order to have some angular distribution information in the low frequency range, we have also constructed a wide band receiver.

2.2 Wide Band Receiver

The wide band receiver is intended to be sensitive to approximately the entire bandwidth of the low frequency receiver, and to have a sufficient short sampling time that angular information can be obtained.
In order to reduce the number of parts required, the wide band receiver and the wave form sampler share the first stages of amplification. The wave form sampler, however, has to have a bandwidth appropriate to the handling mode (bit rate for loading into core storage) and so this also determines the bandwidth of the wide band receiver. These bandwidths will be given under the section for the wave form sampler. A block diagram of the wide band receiver and waveform sampler is shown in FIG. 3.

2.3 Wave Form Sampler

The purpose of the wave form sampler is to sample the instantaneous voltage difference between the antennas, and to convert it to a digital word suitable for telemetry. Wave form sampler data are also referred to as shock data, and are telemetered only in formats 5 and 6. The outputs is essentially the instantaneous voltage from the antenna. Since the sampling rate is finite the signal which is to be sampled must have its high frequency components (frequencies which are more than half the inverse of the sampling rate), removed, otherwise the data will be impossible to interpret. The combined sampling and wide band receivers, therefore, contain a low pass filter whose corner frequency is varied automatically in response to the sampling rate (Data Handling Mode in use). Corner frequencies appropriate to the various handling modes are shown in TABLE II. Above the corner frequency, attenuation of these filters increases by 40 dB per frequency decade. Also in TABLE II are the sampling rates of the waveform sampler.

TABLE II: **MODE FREQUENCIES AND SAMPLING RATES**

Mode	Corner frequency	Time between samples
DM3	150 cps	2.2 msec
DM2	70 cps	4.4
DM1	35 cps	8.8
DM0	20 cps	bit rate dependent

3. COMMANDS AND OPERATION

Experiment 5b has five commands which are as follows: (1) COMMAND 007 (shadow inhibit disable). When the long antennas pass into the shadow of the spacecraft, they no longer emit photo-electrons, and they tend to approach a much different potential than what they have in sunlight, and will therefore produce a pulse at the receiver input. This pulse is expected not to affect the MF and HF receivers, but it would have a serious effect on the LF receiver. Therefore, the latter contains a circuit which disconnects the antenna from the receiver input when the antenna is in shadow. The experiment uses the see-sun pulse to calculate the time when the experiment will be in shadow.
Disconnection of the antenna produces its own deleterious effects so we have made an override command called shadow inhibit disable. When this command is sent, the shadow inhibit circuit no longer works and the antenna remains

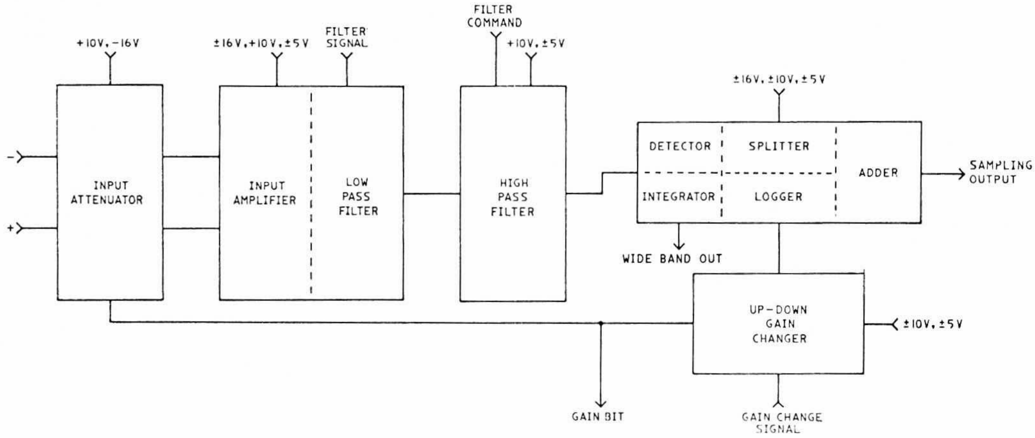

FIG. 3:
Block Diagram Band Pass Receiver

connected to the receiver input for a full revolution. The shadow inhibit circuit is called "holding circuit" in FIG. 2.

(2) COMMAND 217 (high pass filter out). Because of attenuator switching the receivers do not behave well in the presence of a very large low frequency signal because the signal is chopped by the input attenuators and can make spurious signals appear in the high frequency channels. In order to guard against possible strong low frequency signals from the solar array, (1 Hz and 16 Hz), particularly at 1 Hz, we have built a filter which strongly attenuates a one hertz signal. However, again this has a bad effect since we would also like to measure, (if possible), the 1 Hz signal in order to measure the DC electric fields in solar wind. Therefore, this filter is removable by command. The command "high pass filter out" bypasses this filter. The position of the filter is shown in FIG. 3.

(3) COMMAND 370 (impedance measurement and calibrate). This command causes the antenna impedance to be measured, and then a standard calibration signal to be applied to the receiver inputs. The antenna impedance is measured by switching on an oscillator which oscillates at the same frequencies that the receivers are tuned to, and applying its signal through a small (3-pf) capacitor to the antennas. After the oscillator has gone through one measurement cycle, it is turned off, and a signal consisting of filtered square waves derived from the spacecraft clock is applied to the receiver inputs in order to check their calibration. This calibration also lasts one measurement cycle, making a total of 2 measurement cycles. One measurement cycle takes 48 frames in formats 1, 2 and 3 and 96 frames in format 5.
In addition to being commandable, this impedance measurement and calibration sequence is performed every 2^{13} sec on the appropriate spacecraft clock pulse.

(4) COMMAND 305 (Reference oscillator calibrate).
The reference oscillator whose signal is applied to the antenna in order to measure its impedance can be calibrated by switching it directly to the receiver input. This command turns the oscillator on, switches it directly to the receiver input for one measurement cycle and then turns the oscillators off and disconnects it.

(5) COMMAND 160 (Reset). This command erases the effect of all foregoing commands and puts the experiment in a standard mode, which is as follows: high pass filter in, shadow inhibit in, no impedance measurement, and no reference oscillator calibrate. When the experiment is turned on, it automatically goes into the same mode except that it begins with a reference oscillator calibrate.

The Radio Astronomy Experiment on Helios A and B (E 5c)

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The NASA Goddard Space Flight Center radio astronomy experiment on HELIOS, identified as Experiment 5C, has sixteen observing frequencies over the range of 26.5 to 3000 kHz. The antenna consists of two extendible 15-m booms, forming an electric dipole, two high-impedance preamplifiers located at the root of the booms, and the 16-channel radiometer. Important informations about propagation conditions mportant information about propagation conditions,such as absorption, scattering and refraction, are ex pected from observations of radio emission regionsat distances between 1 and 0,3 AU.

Das Radioastronomie-Experiment des NASA Goddard Space Flight Center ist für verschiedene Meßfrequenzen im Bereich von 26,5 bis 3000 kHz ausgelegt. Die Antenne besteht aus zwei ausfahrbaren 15m-Booms als elektrischen Dipol, zwei Vorverstärkern hoher Impedanz direkt an den Antennenwurzeln und dem 16-Kanal-Radiometer. Wichtige Informationen über die Ausbreitungsbedingungen von Radiowellen wie Absorption, Verteilung und Veränderungen werden von den Meßergebnissen über den Bereich von 1,0 bis 0,3 AE erwartet.

1. PHYSICAL ASPECTS OF THE OBSERVATIONS

Radio astronomy experiments conducted in space, beyond the plasmapause, have extended the observations of solar radio bursts from 10 MHz down to near 10 kHz. These observations have shown that type III (fast-drift) traveling disturbances occur in large numbers over this frequency range. According to present understanding of the process responsible for type III emission, a packet of superthermal electrons, ejected for example during a solar flare, travels out through the corona and interplanetary space along magnetic field lines. These "exciter" electrons produce Cerenkov waves, which in part are converted into electromagnetic radiation at twice the local pasma frequency. This radiation thereby provides a measure of the local plasma density. As the exciter moves outward to regions of lower density, the radiation occurs at progressively lower frequencies and later times. The difference in emission times for two frequencies is then equal to the time for the exciter to

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