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NOTE

A Mesospheric Experiment: Measurement Scheme and Program Implementation

by

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A MESOSPHERIC EXPERIMENT : MEASUREMENT SCHEME AND PROGRAM IMPLEMENTATION

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S-981 27 Kiruna Sweden
March 1982
EISCAT Technical Note 82/35
Printed in Sweden
ISSN 0349-2710

INTRODUCTION

This technical note describes the programs proposed for performing a mesospheric experiment. We show the measurement schemes selected and the actual program implementation; and the correlator and radar controller programs.

The program at the EROS level has not been developed yet; this will be done by the EISCAT staff in the near future.

1 - MEASUREMENT SCHEME

Groups from different countries proposed mesospheric experiments which were in general very similar though there were minor differences as to the need to measure clutter.
Mesospheric measurements need a good height resolution (~2 km). For that reason we have to use very short transmission pulses (~20 μsec) or Barker-coded pulses. The theoretical instantaneous signal-to-noise ratio is very low (10^{-3} - 10^{-4} for 20 μsec pulses) and therefore the integration time will be very long. The theoretical mesospheric spectrum will be very narrow and so we cannot use the ordinary multi-pulse mode to measure it. Instead we propose to calculate the correlation function from pulse to pulse. Figure 1 explains this technique.

The transmitter sends the first pulse at time t = 0 and the receiver takes successive samples from different altitudes S_{1,A_1}, S_{1,A_2}, ... S_{1,A_n} where the subscript 1 refers to the first pulse, and the subscript A_i refers to the i'th altitude. The second transmission occurs after a few milliseconds and the receiver is opened to take new data S_{2,A_1}, S_{2,A_2}, ... S_{2,A_n}.

After G pulses are transmitted the buffer memory will be commuted and the correlator will calculate the correlation functions for each altitude :-

$$\rho^{p}_{A_i}(k) = \sum_{j=1}^{G-k} S_{j,A_i} S_{j+k,A_i} \qquad 0 \leqslant k \leqslant G-1$$

The different correlation functions for different blocks of data will be averaged to give an estimate of the desired correlation function :-

$$<\rho_{A_i}(k)> = \sum_{p=1}^{P} \rho^{p}_{A_i}(k)$$

The average of this estimate is then given by :-

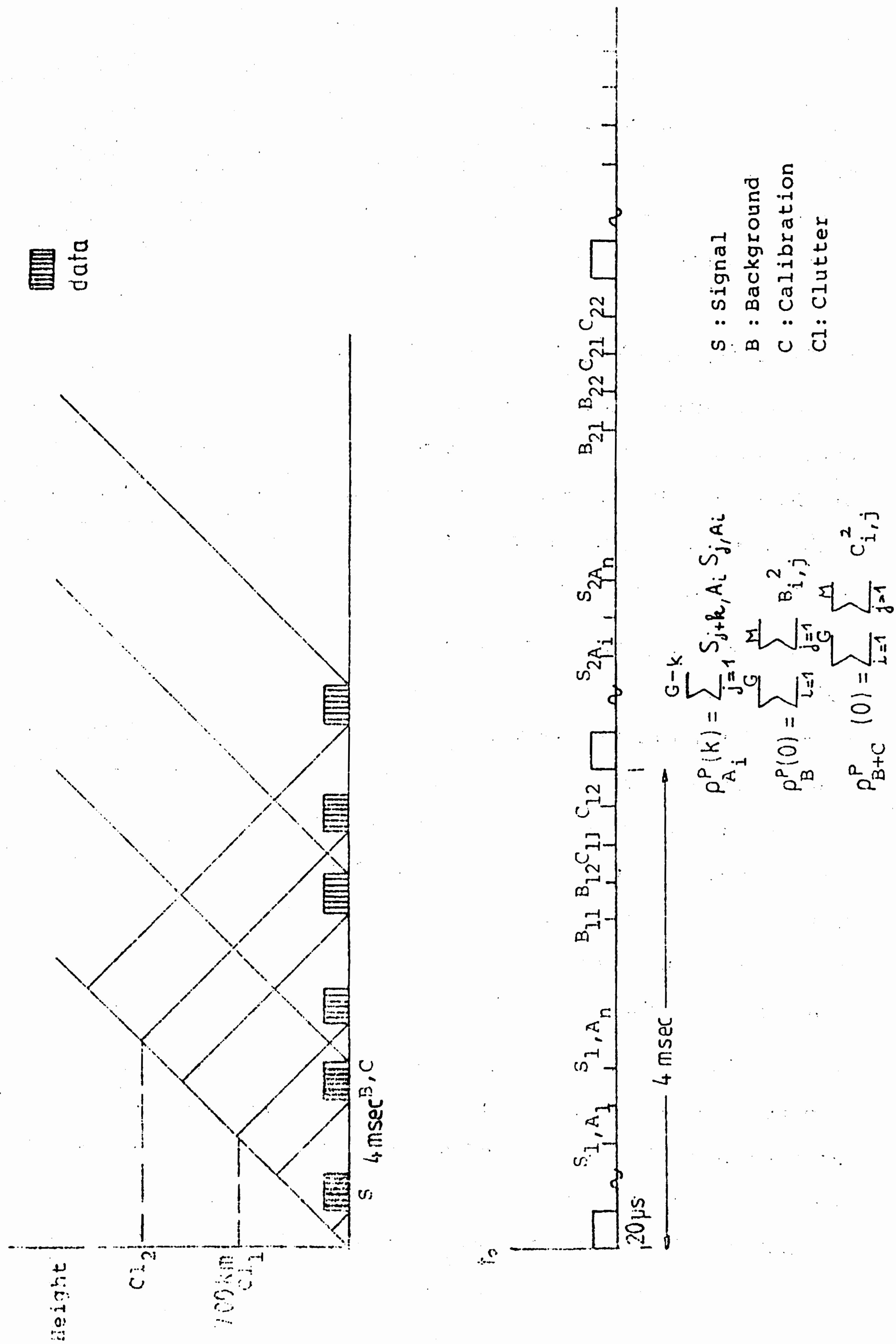
$$<<\rho_{A_i}(k)>> = \rho_{A_i}(k) + P_B\delta(k) + P_{Cl}\delta(k) \qquad \delta(k) = 1 \text{ for } k=0; \; = 0 \text{ for } k\neq 0$$

where P_B is the power of the background noise and P_{Cl} the power of the clutter; $\rho_{A_i}(k)$ represents the correlation function of the medium so that $\rho_{A_i}(0)$ represents the power in the ionic and electronic part of the analysed bandwidth and $\rho_{A_i}(k)$ for $k\neq 0$ the correlation function corresponding to the ionic part of the spectrum.

The term due to background noise only perturbs the first point in the correlation function as the bandwidth of the noise is much larger than the bandwidth of the measured signal (N.B. a good height resolution requires a short pulse and hence a wide receiver bandwidth). The third term is due to clutter received from greater altitudes, as shown in Fig. 1.

The first clutter-to-noise ratio, Cl_1/B, is $\sim 10^{-2}$ for the typical experiment using a 4 msec pulse-repetition-rate and a 20 μsec pulse. The second clutter-to-noise ratio, Cl_2/B, is $\sim 10^{-7} - 10^{-9}$. As the typical signal-to-noise ratio is $10^{-3} - 10^{-4}$ it is only necessary to remove clutter from the first height. Indeed, as the ionic part of the first point in the correlation function can easily be

FIGURE 1


data
Height
Cl_2
100 km
Cl_1
S
4 msec
B, C
t_0
20µs
4 msec
S_{1,A_1}
S_{1,A_n}
B_{11} B_{12} C_{11} C_{12}
S_{2A_1}
S_{2A_n}
B_{21} B_{22} C_{21} C_{22}
$\rho^P_{A_i}(k) = \sum_{j=1}^{G-k} S_{j+k,A_i} S_{j,A_i}$
$\rho^P_B(0) = \sum_{i=1}^{G} \sum_{j=1}^{M} B^2_{i,j}$
$\rho^P_{B+C}(0) = \sum_{i=1}^{G} \sum_{j=1}^{M} C^2_{i,j}$
S : Signal
B : Background
C : Calibration
Cl: Clutter

extrapolated from the other lags, but in order to normalise the data correctly it is necessary to measure the first point. At this stage it is not certain which method is better and so the proposed scheme of measurement allows the correlation function to be determined with or without the removal of clutter. The same correlator program can be used in both cases and only the radar controller program need be changed.

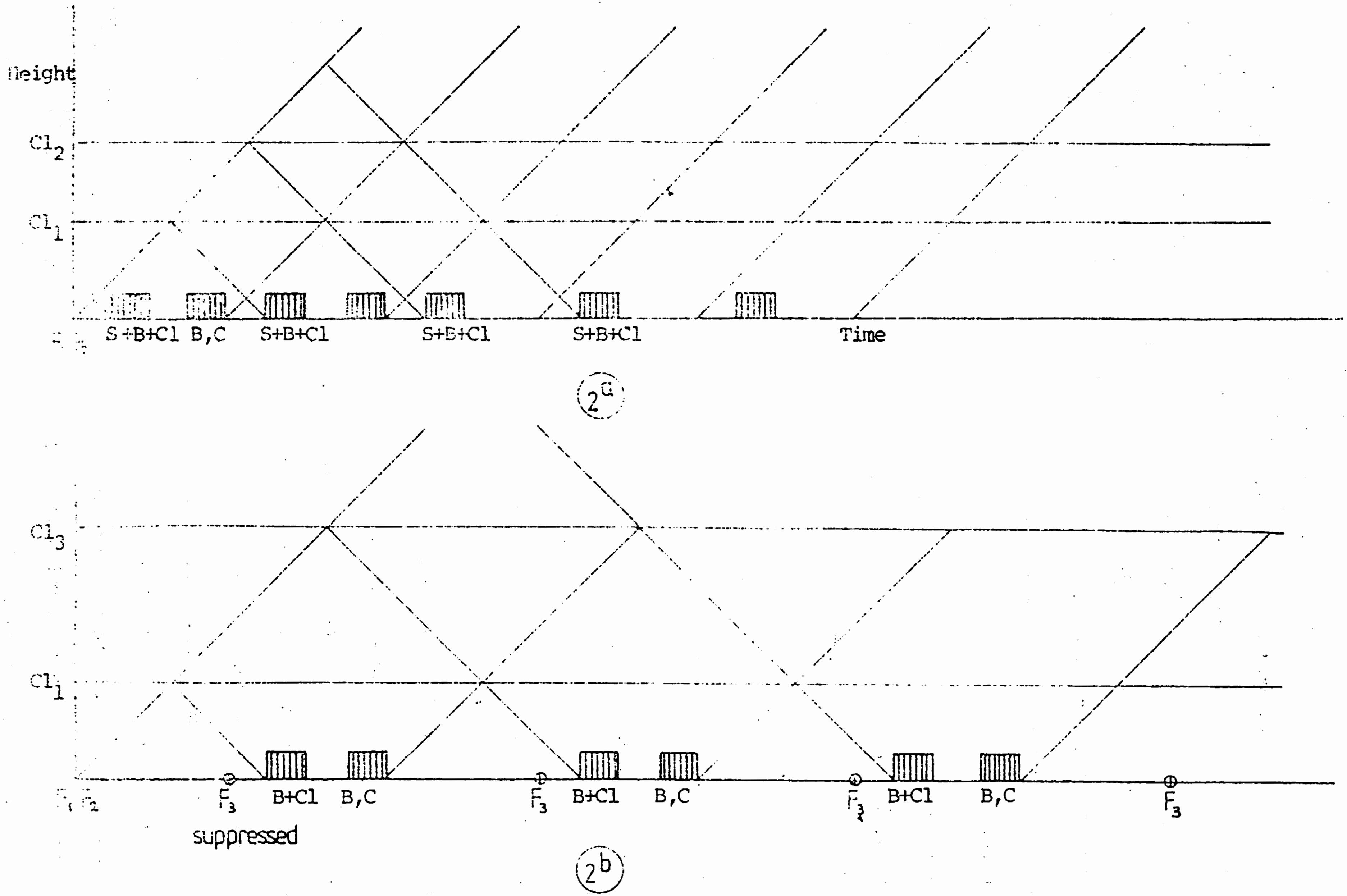
a) The pulse scheme without clutter measurement

The measurement scheme is plotted in Fig. 2. The pulse-repetition-period will be typically 4 msec which gives an available bandwidth of 250 Hz for the measured spectrum, as the receiver provides both quadrature components. The spectral resolution depends on the number of lags measured and will probably be a few Hz.

For a 4 msec repetition period, the first clutter comes from a height of 600 - 700 km. Calibration and background noise are measured immediately before the next pulse is transmitted. If clutter is neglected these measurements of the calibration signal and the background noise allow us to normalise the total scattered power correctly in order to measure the component due to the electrons. When clutter is too strong, however, extrapolation must be used to estimate the first point of the correlation function for the ionic part of the spectrum.

To make full use of the capabilities of the transmitter at least two frequencies will be used, and the pulses will probably be Barker-coded. The Barker codes ameliorate the instantaneous signal-to-noise ratio for the same height resolution as before, but the secondary lobe effect can be a serious problem. Possibly the use of the complementary codes will be necessary.

FIGURE 2



2^a : we measure signal+background+clutter; background+clutter; and background+calibration+clutter.

2^b : we measure background+clutter; background; and background+calibration.

b) The pulse scheme with clutter measurement

We propose a simple scheme of measurement which permits us to obtain every other order of clutter (i.e. $Cl_1, Cl_3, Cl_5 ...$). For an initial period of, say, 10 seconds the previous scheme of measurement is used; for the next 10 seconds every alternative pulse is suppressed so that the new mode will measure the background noise plus the clutter from heights 1, 3, 5 etc. (see Fig. 2). In this scheme a third transmitter frequency is used so that the clutter measurements can correspond exactly to the mesospheric signal measurements.

In this scheme the time resolutions is worse by a factor of two. In order to change from one scheme to the other it is only necessary to reload the TARLAN program as the correlator program is the same in both cases.

2 - PROGRAM DESCRIPTION

a) Pulse generation (TARLAN)

The radar controller (RC) which controls the timing of the transmitted and received pulses does not allow loops inside a program. At the end of each cycle of measurement the RC sends a "start-compute" signal to the correlator and restarts a new cycle. At this stage the two halves of the buffer memory are commuted. This mode is not really suitable for an experiment making pulse-to-pulse correlation measurements because we have to fill one half of the buffer memory with many samples corresponding to different pulses before starting the calculation and commuting the buffer memory, and so we should not send the "start-compute" order before filling one half of the buffer memory. This implies that the scheme is limited either by the size of the buffer memory (4K for each half) or by the size of the RC (4K) which limits the number of instructions that we can program.

From the statistical point of view it is desirable to have the number of samples much larger than the number of calculated lags. This is due to the fact that it is not possible to calculate the correlation between samples in the two halves of the buffer memory. The equations describing the limitations of the buffer and result memory are :-

$$(n_A + n_B + n_C) \times n_F \times G = 4096$$

$$n_L \times n_A \times n_F + 2n_F = 2048$$

where n_A are the number of samples corresponding to different altitudes

n_B are the number of samples corresponding to the background measurements

n_C are the number of samples corresponding to the calibration measurements

n_F are the number of frequencies

n_G are the number of pulses transmitted in each cycle and

n_L are the number of lags measured.

A program generating the TARLAN instructions for a typical experiment is shown in Annex 1. The pulses are transmitted on two frequencies, and two receiver channels take the data separately for 8 signal, 4 background and 4 calibration samples. This program gives almost optimal filling of RC by TARLAN instructions and of the buffer memory by samples.

In this case 200 pulse-repetition-periods are used to produce each correlation function. The long pulse on F4 will be received in Kiruna and Sodankylä to measure both the ionic and electronic parts of the spectrum.

b) Correlator program

i) Program without coherent integration

This program calculates the correlation function for each altitude, the power for background and calibration (Fig. 2) adding the power for all samples (see Annex 2). The registers of the APB, APM processors must be defined in the main program in EROS.

	Register name	Register address	Parameters
APB	RS (15)	16,15	No. of pulses transmitted - 1
APB	RS (14)	16,14	No. of range gates - 1 (signal)
APB	RS (13)	16,13	No. of lags - 1 (signal)
APB	RS (12)	16,12	- (RS (15) x RS (11) - 1)
APB	RS (11)	16,11	No. of altitudes + no. of background samples + no. of calibration samples.
APB	RS (8)	16,8	No. of background samples - 1
APB	RS (7)	16,7	No. of calibration samples - 1
APB	RS (6)	16,6	No. of frequencies
APB	RS (5)	16,5	1
APB	RS (3)	16,3	Address increment between the end of the data corresponding to one frequency and the beginning of the data corresponding to another.
APM	RS (15)	17,15	Range gate increment (= no. of lags for each correlation function)
APM	RS (14)	17,14	1
APM	RS (0)	17,0	Increment for transfer = 1

I register APB = no. of words to transfer + 1.

ii) Program with coherent integration (developed by Regi Gras)

The correlation function varies slowly in the D region. When the temporal separation between samples from the same altitude is much shorter than the correlation time, we can use coherent integration. For instance, for a spectrum of 10 Hz bandwidth the correlation time is about 0.1 seconds and for this we can always add two successive samples at a 4 msec separation. The amplitude of these two samples is almost the same due to the high correlation and so the signal-to-noise ratio is improved by a factor of 1.41. This technique can be very useful for mesospheric measurements.

For instance let $S_1, S_2, \ldots S_G$ be the samples for one altitude; then the program calculates the correlation function :-

$$\rho(k) = \sum_{i=1}^{P} a_i a_{i+k}^{*} \quad \text{where } a_i = \sum_{j=1}^{H} S_{i+j}$$

where H is the number of samples summed coherently. This program calculates the background and calibration powers as in the previous case (see Annex 3)

Acknowledgements

I wish to thank Terrance Ho, Bård Törustad and Regi Gras for the help in program preparation.

ANNEX 1

Program to generate the TARLAN instructions for 200 p.r.p.

```
      [illegible]
      OUTPUT(10)'TROMSO'
C NUMBER OF SAMPLES FOR ONE SCAN EQUAL NUMBER OF REPETITION OF THIS
C PROGRAM. THE LIMITATION BY RADAR CONTR. MEMORY ONLY 4096 WORDS
C NUMBER OF SAMPLES(MAX)=200,NOT OPTIMAL USE OF DATA
C OPTIMAL USE OF DATA IS NUMBER OF SAMPLES>NUMBER OF LAGS DUE TO
C SPLIT INTO TWO PARTS OF BUFFER MEMORY.THIS LIMITATION ONLY FOR
C MESOSPHERIC EXPERIMENT.
C POSSIBILITY TO USE THE SECOND COUNTER IN RC TO AVOID THE
C REPETITION. HOW TO DO IT?
C 4000=TIME BETWEEN TRANSMISSIONS,SAMPLING RATE FOR CORRELATION MEAS.
      DO FOR I=1,200
      OUTPUT(10)'SETTCR',(I-1)*4000
      OUTPUT(10)'AT 1 TRANS'
      OUTPUT(10)'AT 2 SYSON'
      OUTPUT(10)'AT 5 HVON'
      OUTPUT(10)'AT 35 F4'
      OUTPUT(10)'AT 635 F1'
      OUTPUT(10)'AT 655 F2'
      OUTPUT(10)'AT 675 FOFF HVOFF'
      OUTPUT(10)'AT 677 SYSOFF'
      OUTPUT(10)'AT 750 RECEV'
      OUTPUT(10)'AT 1035 CH1'
      OUTPUT(10)'AT 1055 CH2'
C SAMPLING RATE=20USEC ON CH1 AND CH2
C DATA START ON 60 KM WITH 3.0 KM RESOLUTION
C TO HAVE EXACTE NUMBER OF SAMPLES
C TOFF=TON+(N-1)*TSAMP+TSAMPL/2
      OUTPUT(10)'AT 1185 CH1OFF'
      OUTPUT(10)'AT 1205 CH2OFF'
      OUTPUT(10)'AT 3800 CH1 CH2'
      OUTPUT(10)'AT 3870 ALLOFF'
      OUTPUT(10)'AT 3872 CAL30'
      OUTPUT(10)'AT 3922 CH1 CH2'
      OUTPUT(10)'AT 3992 ALLOFF'
      OUTPUT(10)'AT 3997 CAL0'
      ENDDO
      OUTPUT(10)'SETTCR',800000
      OUTPUT(10)'AT 1 TRANS'
      OUTPUT(10)'AT 2 SYSON'
      OUTPUT(10)'AT 5 HVON'
      OUTPUT(10)'AT 35 F4'
      OUTPUT(10)'AT 635 F1'
      OUTPUT(10)'AT 655 F2'
      OUTPUT(10)'AT 675 FOFF HVOFF'
      OUTPUT(10)'AT 677 SYSOFF'
      OUTPUT(10)'AT 750 RECEV'
      OUTPUT(10)'AT 1035 CH1'
      OUTPUT(10)'AT 1055 CH2'
C SAMPLING RATE=20USEC ON CH1 AND CH2
C DATA START ON 60 KM WITH 3.0 KM RESOLUTION
C TO HAVE EXACTE NUMBER OF SAMPLES
C TOFF=TON+(N-1)*TSAMP+TSAMPL/2
      OUTPUT(10)'AT 1185 CH1OFF'
      OUTPUT(10)'AT 1205 CH2OFF'
      OUTPUT(10)'AT 3800 CH1 CH2'
      OUTPUT(10)'AT 3870 ALLOFF'
      OUTPUT(10)'AT 3872 CAL30'
      OUTPUT(10)'AT 3922 CH1 CH2'
      OUTPUT(10)'AT 3983 STC'
      OUTPUT(10)'AT 3990 STCOFF'
      OUTPUT(10)'AT 3992 ALLOFF
      OUTPUT(10)'AT 3994 CAL0'
      OUTPUT(10)'AT 3995 SFP'
      OUTPUT(10)'END'
```

```
      [illegible]
      OUTPUT(10)'TRONSO'
C NUMBER OF SAMPLES FOR ONE SCAN EQUAL NUMBER OF REPETITION OF THIS
C PROGRAM. THE LIMITATION BY RADAR CONTR. MEMOR: ONLY 4096 WORDS
C NUMBER OF SAMPLES(MAX)=200,NOT OPTIMAL USE OF DATA
C OPTIMAL USE OF DATA IS NUMBER OF SAMPLES.(NUMBER OF LAGS DUE TO
C SPLIT INTO TWO PARTS OF BUFFER MEMORY,THIS LIMITATION ONLY FOR
C MESOSPHERIC EXPERIMENT.
C POSSIBILITY TO USE THE SECOND COUNTER [illegible] TO AVOID THE
C REPETITION. HOW TO DO IT?
C 4000=TIME BETWEEN TRANSMISSIONS,SAMPLING RATE FOR CORRELATION MEAS.
      DO FOR I=1,200
      OUTPUT(10)'SETTCR',(I-1)*4000
      OUTPUT(10)'AT 1 TRANS'
      OUTPUT(10)'AT 2 SYSON'
      OUTPUT(10)'AT 5 HVON'
      OUTPUT(10)'AT 35 F4'
      OUTPUT(10)'AT 635 F1'
      OUTPUT(10)'AT 655 F2'
      OUTPUT(10)'AT 675 FOFF HVOFF'
      OUTPUT(10)'AT 677 SYSOFF'
      OUTPUT(10)'AT 750 RECEV'
      OUTPUT(10)'AT 1035 CH1'
      OUTPUT(10)'AT 1055 CH2'
C SAMPLING RATE=20USEC ON CH1 AND CH2
C DATA START ON 60 KM WITH 3.0 KM RESOLUTION
C TO HAVE EXACTE NUMBER OF SAMPLES
C TOFF=TON+(N-1)*TSAMP+TSAMPL/2
      OUTPUT(10)'AT 1185 CH1OFF'
      OUTPUT(10)'AT 1205 CH2OFF'
      OUTPUT(10)'AT 3800 CH1 CH2'
      OUTPUT(10)'AT 3870 ALLOFF'
      OUTPUT(10)'AT 3872 CAL30'
      OUTPUT(10)'AT 3922 CH1 CH2'
      OUTPUT(10)'AT 3992 ALLOFF'
      OUTPUT(10)'AT 3997 CALO'
      ENDDO
      OUTPUT(10)'SETTCR',800000
      OUTPUT(10)'AT 1 TRANS'
      OUTPUT(10)'AT 2 SYSON'
      OUTPUT(10)'AT 5 HVON'
      OUTPUT(10)'AT 35 F4'
      OUTPUT(10)'AT 635 F1'
      OUTPUT(10)'AT 655 F2'
      OUTPUT(10)'AT 675 FOFF HVOFF'
      OUTPUT(10)'AT 677 SYSOFF'
      OUTPUT(10)'AT 750 RECEV'
      OUTPUT(10)'AT 1035 [illegible]'
      OUTPUT(10)'AT [illegible] [illegible]'
C SAMPLING RATE=20USEC ON CH1 AND CH2
C DATA START ON 60 KM WITH [illegible] KM RESOLUTION
C TO HAVE EXACTE NUMBER OF SAMPLES
C TOFF=TON+(N-1)*TSAMP+TSAMPL/2
      OUTPUT(10)'AT 1185 CH1OFF'
      OUTPUT(10)'AT 1205 CH2OFF'
      OUTPUT(10)'AT 3800 CH1 CH2'
      OUTPUT(10)'AT 3870 ALLOFF'
      OUTPUT(10)'AT 3872 CAL30'
      OUTPUT(10)'AT 3922 CH1 CH2'
      OUTPUT(10)'AT 3988 STC'
      OUTPUT(10)'AT 3990 STCOFF'
      OUTPUT(10)'AT 3992 ALLOFF'
      OUTPUT(10)'AT 3994 CALO'
      OUTPUT(10)'AT [illegible] [illegible]'
      OUTPUT([illegible]
```

ANNEX 2

<u>Pulse-to-pulse correlation (with number of lags less than number of samples) plus power measurements.</u>

Memory Location		PRO	APB	APM
00				
01			RS(4)=RS(6)	
02				
03		Reload LCR1 ←	RS(4)	
04				
05		LC1 = LCR1		
06	Yes	◇ LC1	RS(4)=RS(4)-1	
07		Reload LCR1	RS(15)	
08				
09		Reload LCR2	RS(14)	
10				
11		Reload LCR3	RS(13)	
12		CALL SUB. Pulse-to-pulse.		
13		Reload LCR2	RS(8)	
14		CALL POWER	Q=Q+RS(12)	Q=Q+Range gate increment
15		Reload LCR2	RS(7)	
16		CALL POWER	Q=RS(12)+Q	Q=Q+1
17		GO TO → (to 03)		
18		→	Incrementation of scan count	
19		GO TO 0 (END)		SET FF2

X X X CORRELATOR SIMULATOR X X X

PROGRAM NAME : FRENCH EXPERIMENT.

CODING (INTEGER) OF SEPARATE CORRELATOR FUNCTIONS

PROGRAM-INSTRUCTIONS DEFINED

MEM-LOC.	COND.CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
0	56	0	4	0	0	0	0	0	0	0
1	56	0	4	0	0	0	0	0	0	0
2	56	0	4	0	0	0	0	0	0	0
3	56	0	4	0	0	0	0	0	1	18
4	56	0	4	0	0	0	0	0	0	0
5	56	0	4	0	2	0	0	0	0	0
6	57	6	4	18	0	0	0	0	0	0
7	56	0	4	0	0	0	0	0	1	18
8	56	0	4	0	0	0	0	0	0	0
9	56	0	4	0	0	0	0	0	1	19
10	56	0	4	0	0	0	0	0	0	0
11	56	0	4	0	0	0	0	0	1	20
12	56	0	10	20	0	0	0	0	0	0
13	56	0	4	0	0	0	0	0	1	19
14	56	0	10	45	0	0	0	0	0	0
15	56	0	4	0	0	0	0	0	1	19
16	56	0	10	45	0	0	0	0	0	0
17	56	0	4	3	0	0	0	0	0	0
18	56	0	4	0	0	0	0	0	0	0
19	56	0	4	0	0	0	0	0	0	0
20	56	0	4	0	2	0	3	2	0	0
21	61	6	4	26	1	0	0	1	0	0
22	61	6	4	24	1	1	0	1	0	0
23	61	4	4	23	1	0	0	1	0	0
24	56	0	4	0	3	0	0	2	0	0
25	57	4	6	27	6	0	0	1	0	0
26	58	4	6	21	2	0	1	2	0	0
27	56	0	4	0	0	0	0	0	0	0
28	56	0	4	0	0	0	0	0	0	0
29	56	0	4	0	0	0	0	0	0	0
30	56	0	4	0	0	0	0	0	0	0
31	56	0	4	0	0	0	0	0	0	0
32	56	0	4	0	0	0	0	0	1	20
33	56	0	4	0	0	0	0	0	0	0
34	56	0	4	0	0	0	0	0	0	0
35	56	0	4	0	0	0	0	0	0	0
36	56	0	4	0	0	0	0	0	0	0
37	56	0	4	0	0	0	0	1	0	0
38	56	0	4	0	0	0	0	0	0	0
39	56	0	4	0	0	0	0	0	0	0
40	60	0	5	0	0	0	0	0	0	0
41	56	0	4	0	0	0	0	0	0	0
42	56	0	4	0	0	0	0	0	0	0
43	56	0	4	0	0	0	0	0	0	0
44	56	0	4	0	0	0	0	0	0	0
45	56	0	4	0	2	0	3	0	0	0
46	57	6	4	50	1	0	0	0	0	0
47	57	6	4	49	1	0	0	0	0	0
48	57	4	6	48	1	0	0	0	0	0
49	56	0	4	0	0	0	0	0	0	0
50	58	4	6	44	2	0	1	0	0	0
51	56	0	1	0	0	0	0	0	0	0

APB-INSTRUCTIONS DEFINED

MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT
0	7	5	1	0	0	0
1	4	0	3	6	4	0
2	7	5	0	0	0	0
3	4	0	1	4	0	0
4	7	5	1	0	0	0
5	7	5	1	0	0	0
6	1	1	3	5	4	0
7	4	0	1	15	0	0
8	7	5	1	0	0	0
9	4	0	1	14	0	0
10	7	5	1	0	0	0
11	4	0	1	13	0	0
12	7	5	1	0	0	0
13	4	0	1	8	0	0
14	0	0	0	12	0	0
15	4	0	1	7	0	0
16	0	0	0	12	0	0
17	0	0	0	3	0	0
18	7	5	1	0	0	0
19	7	5	1	0	0	0
20	0	1	0	12	0	0
21	0	0	0	12	0	0
22	0	0	3	11	10	0
23	1	0	3	11	10	0
24	7	5	1	0	0	0
25	0	0	0	11	0	0
26	7	5	1	0	0	0
27	7	4	1	0	0	0
28	7	4	1	0	0	0
29	7	4	1	0	0	0
30	7	4	1	0	0	0
31	7	4	1	0	0	0
32	7	0	1	0	0	0
33	7	5	1	0	0	0
34	7	5	1	0	0	0
35	[illegible]	5	1	0	0	0
36	7	5	1	0	0	0
37	7	5	1	0	0	0
38	7	5	1	0	0	0
39	7	5	1	0	0	0
40	7	5	1	0	0	0
41	7	5	1	0	0	0
42	7	5	1	0	0	0
43	7	5	1	0	0	0
44	7	5	1	0	0	0
45	0	1	0	12	0	0
46	0	0	0	12	0	0
47	2	0	1	0	0	0
48	0	0	0	11	0	0
49	0	0	0	11	0	0
50	7	5	1	0	0	0
51	7	5	1	0	0	0

APM-INSTRUCTIONS DEFINED

MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.
0	7	5	1	0	0
1	7	5	1	0	0
2	7	5	0	0	0
3	7	5	1	0	0
4	7	5	1	0	0
5	7	5	1	0	0
6	7	5	1	0	0
7	7	5	1	0	0
8	7	5	1	0	0
9	7	5	1	0	0
10	7	5	1	0	0
11	7	5	1	0	0
12	7	5	1	0	0
13	7	5	1	0	0
14	0	0	0	15	0
15	7	5	1	0	0
16	0	0	0	14	0
17	0	0	0	14	0
18	2	0	1	0	0
19	7	5	1	0	0
20	0	1	0	15	0
21	0	0	0	15	0
22	0	0	3	14	13
23	1	0	3	14	13
24	7	5	1	0	0
25	2	0	1	0	0
26	7	5	1	0	0
27	7	4	1	0	0
28	7	4	1	0	0
29	7	4	1	0	0
30	7	4	1	0	0
31	4	0	3	15	3
32	7	5	1	0	0
33	7	5	1	0	0
34	7	5	1	0	0
35	7	5	0	0	0
36	0	1	0	0	0
37	0	0	0	0	0
38	2	0	1	0	[illegible]
39	2	0	1	0	[illegible]
40	2	0	1	0	0
41	7	5	1	0	0
42	7	5	1	0	0
43	7	5	1	0	0
44	7	5	1	0	0
45	7	5	1	0	0
46	2	0	1	0	0
47	7	5	1	0	0
48	7	5	1	0	0
49	2	0	1	0	0
50	7	5	1	0	0
51	2	0	1	0	0

ARITHMETICAL INSTRUCTIONS DEFINED

MEM-LOC.	M1A	M1B	M2A	M2B	M3A	M3B	M4A	M4B	SM1	SM2	SM3	SM4	M12	M34
0	0	0	0	0	0	0	0	0	0	0	0	0	15	15
1	0	0	0	0	0	0	0	0	0	0	0	0	15	15
2	0	0	0	0	0	0	0	0	0	0	0	0	15	15
3	0	0	0	0	0	0	0	0	0	0	0	0	15	15
4	0	0	0	0	0	0	0	0	0	0	0	0	15	15
5	0	0	0	0	0	0	0	0	0	0	0	0	15	15
6	0	0	0	0	0	0	0	0	0	0	0	0	15	15
7	0	0	0	0	0	0	0	0	0	0	0	0	15	15
8	0	0	0	0	0	0	0	0	0	0	0	0	15	15
9	0	0	0	0	0	0	0	0	0	0	0	0	15	15
10	0	0	0	0	0	0	0	0	0	0	0	0	15	15
11	0	0	0	0	0	0	0	0	0	0	0	0	15	15
12	0	0	0	0	0	0	0	0	0	0	0	0	15	15
13	0	0	0	0	0	0	0	0	0	0	0	0	15	15
14	0	0	0	0	0	0	0	0	0	0	0	0	15	15
15	0	0	0	0	0	0	0	0	0	0	0	0	15	15
16	0	0	0	0	0	0	0	0	0	0	0	0	15	15
17	0	0	0	0	0	0	0	0	0	0	0	0	15	15
18	0	0	0	0	0	0	0	0	0	0	0	0	12	12
19	0	0	0	0	0	0	0	0	0	0	0	0	15	15
20	0	0	0	0	0	0	0	0	0	0	0	0	15	15
21	0	0	1	1	1	0	0	1	3	3	3	3	9	6
22	0	0	1	1	1	0	0	1	2	2	2	2	9	6
23	0	0	1	1	1	0	0	1	2	2	2	2	9	6
24	0	0	0	0	0	0	0	0	0	0	0	0	15	15
25	0	0	1	1	1	0	0	1	3	3	3	3	9	6
26	0	0	0	0	0	0	0	0	0	0	0	0	15	15
27	0	0	0	0	0	0	0	0	0	0	0	0	12	12
28	0	0	0	0	0	0	0	0	0	0	0	0	12	12
29	0	0	0	0	0	0	0	0	0	0	0	0	12	12
30	0	0	0	0	0	0	0	0	0	0	0	0	12	12
31	0	0	0	0	0	0	0	0	0	0	0	0	12	12
32	0	0	0	0	0	0	0	0	0	0	0	0	15	15
33	0	0	0	0	0	0	0	0	0	0	0	0	15	15
34	0	0	0	0	0	0	0	0	0	0	0	0	15	15
35	0	0	0	0	0	0	0	0	0	0	0	0	15	15
36	0	0	0	0	0	0	0	0	0	0	0	0	15	15
37	0	0	0	0	0	0	0	0	0	0	0	0	15	15
38	0	0	0	0	0	0	0	0	0	0	0	0	15	15
39	0	0	0	0	0	0	0	0	0	0	0	0	15	15
40	0	0	0	0	0	0	0	0	0	0	0	0	15	15
41	0	0	0	0	0	0	0	0	0	0	0	0	15	15
42	0	0	0	0	0	0	0	0	0	0	0	0	15	15
43	0	0	0	0	0	0	0	0	0	0	0	0	15	15
44	0	0	0	0	0	0	0	0	0	0	0	0	15	15
45	0	0	0	0	0	0	0	0	0	0	0	0	15	15
46	0	0	1	1	4	0	4	1	3	3	3	3	9	9
47	0	0	0	0	0	0	0	0	3	3	3	3	6	6
48	0	0	1	1	4	0	4	1	3	3	3	3	9	9
49	0	0	1	1	4	0	4	1	3	3	3	3	9	9
50	0	0	0	0	0	0	0	0	3	3	3	3	6	6
51	0	0	0	0	0	0	0	0	3	3	3	3	6	6

ACCUMULATOR INSTRUCTIONS DEFINED

MEM-LOC.	STROBE I/O	WRITE	READ	CLEAR1	SET1	CLEAR2	SET2
0	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0
2	1	0	0	0	0	0	0
3	1	0	0	0	0	0	0
4	1	0	0	0	0	0	0
5	1	0	0	0	0	0	0
6	1	0	0	0	0	0	0
7	1	0	0	0	0	0	0
8	1	0	0	0	0	0	0
9	1	0	0	0	0	0	0
10	1	0	0	0	0	0	0
11	1	0	0	0	0	0	0
12	1	0	0	0	0	0	0
13	1	0	0	0	0	0	0
14	1	0	0	0	0	0	0
15	1	0	0	0	0	0	0
16	1	0	0	0	0	0	0
17	1	0	0	0	0	0	0
18	1	1	1	1	0	0	0
19	1	0	0	0	0	0	1
20	1	0	0	0	0	0	0
21	1	1	1	1	0	0	0
22	1	1	1	0	0	0	0
23	1	1	1	0	0	0	0
24	1	0	0	0	0	0	0
25	1	1	1	0	1	0	0
26	1	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
32	0	0	0	0	0	1	0
33	0	0	0	0	0	1	0
34	0	0	0	0	0	1	0
35	0	0	0	0	0	1	0
36	0	0	0	0	0	1	0
37	0	0	0	0	0	1	0
38	0	0	0	0	0	1	0
39	0	0	0	0	0	1	0
40	0	0	0	0	0	1	0
41	0	0	0	0	0	1	0
42	0	0	0	0	0	1	0
43	0	0	0	0	0	1	0
44	0	0	0	0	0	1	0
45	1	0	0	1	0	0	0
46	1	0	1	0	0	0	0
47	1	0	0	0	0	0	0
48	1	0	0	0	0	0	0
49	1	1	0	0	1	0	0
50	1	0	0	0	0	0	0
51	1	1	0	0	0	0	0

I/O INSTRUCTIONS DEFINED.

MEM-LOC.	SETF	CLEARF	SELECT BUF.ADDR.	STROBE I-REG.	ENABLE EDB	ENABLE EAB
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0

OUTPUT-TRANSFER INSTRUCTIONS DEFINED

MEM-LOC.	TRANSFER	INHIBIT CLOCK	DATA-READY	TRANSFER-CODE	SOURCE
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	[illegible]	0	0	0
8	0	[illegible]	0	0	0
9	0	[illegible]	0	0	0
10	0	[illegible]	0	0	0
11	0	[illegible]	0	0	0
12	0	[illegible]	0	0	0
13	0	[illegible]	0	0	0
14	0	[illegible]	0	0	0
15	0	[illegible]	0	0	0
16	0	[illegible]	0	0	0
17	0	[illegible]	0	0	0
18	0	[illegible]	0	0	0
19	0	[illegible]	0	0	0
20	0	[illegible]	0	0	0
21	0	[illegible]	0	0	0
22	0	[illegible]	0	0	0
23	0	[illegible]	0	0	0
24	0	[illegible]	0	0	0
25	0	[illegible]	0	0	0
26	0	0	0	0	0
27	1	0	0	0	0
28	1	0	0	0	0
29	1	0	0	0	0
30	1	0	0	0	0
31	1	0	0	0	0
32	0	0	0	0	0
33	0	0	0	0	0
34	1	0	0	0	0
35	1	1	1	0	0
36	1	1	1	1	0
37	1	1	1	3	0
38	1	1	1	2	0
39	1	1	1	5	0
40	1	1	1	4	0
41	1	0	0	0	0
42	1	0	0	0	0
43	1	0	0	0	0
44	1	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	0	0	0	0	0
48	0	0	0	0	0
49	0	0	0	0	0
50	0	0	0	0	0
51	0	0	0	0	0

ANNEX 3

Program with coherent integration.

APB STACK

RS (15)	No. of points to add - 1
RS (14)	No. of sçan / No. of points to add - 1
RS (13)	No. of range gates - 1
RS (12)	Sample increment (Signal + Background + Calibration)
RS (11)	(Sample increment x NO. of scan - 1)
RS (10)	RS (14)
RS (9)	Increment 2 (Sample increment x No. of points to add)
RS (8)	Increment 1
RS (7)	No. of noise samples - 1 AND No. of calibration samples - 1
RS (6)	No. of scan - 1
RS (5)	No. of frequencies
RS (4)	RS (5)
RS (3)	Temporary storage 1
RS (2)	Running address
RS (1)	Temporary storage 2
RS (0)	Free

APM STACK

RS (15)	Range-gate increment (No. of scan/No. of points to add)
RS (14)	1
RS (0)	1

DATA-I-REGISTER

DATA-I-REG = No. of frequencies x (Range-gate increment x No. of ranges + 2)

Memory Location	PRO	APB	APM	ARI	ACC
01	DEB: Reload LCR2	RS(14)			
02					
03	LC1=LCR1;LC2=LCR2	TS1=Q		Load A without computation	Clear FF1
04		TS2=Q			
05	LCR1A=LC1;LC1=LC1-1;LC2=LC2-1	Running address =TS1	TS=Q	Load B with computation	
06	LC2=0 — No: LC2=LC2-1; Yes	Ru.add.=Ru.add.+INC2	TS=TS+1	Load B with computation	
07	E1: LC2=LCR2	TS2=TS2+Sample increment			Set FF1
08	LC2=0 — Yes; No;LC2=LC2-1	Ru.add=TS2	TS=TS+1	Load B with computation	
09	LC2=0 — No: LC2=LC2-1; LC2=LCR2				
10	LC1=0 — No: LC1=LC1-1; Yes				
11	LC1=LCR1A	Q=Q+Sample increment		Load A without computation	
12	LC1=0 — Yes; No; LC1=LC1-1	TS2=TS1			
13	LCR1A=LC1;LC1=LCR1	TS2=TS2-Sample increment			
14	LC1=LCR1;LC2=LCR2	RS(10)=RS(10)-1			
15	LC2=0 — Yes; No				
16	Reload LCR2	RS(10)			
17					
18	LCR1A=LC1;LC2=LCR2	TS1=Q			
19	GO TO E1	TS2=TS2-Sample increment			
20	LC3=0 — Yes: Return; No;LC3=LC3-1	RS(10)=RS(14)	Q=Q+range-gate increment		
21	GO TO DEB	Q=Q-RS(11)			

CODING (INTEGER) OF SEPARATE CORRELATOR FUNCTIONS

PROGRAM-INSTRUCTIONS DEFINED

MEM-LOC.	CONO.CODE	CODE-B	CODE-A	ADDR.	LC1	LC1A	LC2	LC3	RELOAD	R-ADDR.
0	56	0	4	0	0	0	0	0	0	0
1	32	6	4	0	0	0	0	0	0	0
2	32	6	4	0	0	0	0	0	0	0
3	32	6	4	0	0	0	0	0	1	18
4	32	6	4	0	0	0	0	0	0	0
5	32	6	4	0	2	0	0	0	0	0
6	57	6	4	53	0	0	0	0	0	0
7	32	6	4	0	0	0	0	0	1	20
8	32	6	4	0	0	0	0	0	0	0
9	32	6	4	0	0	0	0	0	1	18
10	32	6	6	45	0	0	0	0	0	0
11	32	6	4	0	0	0	0	0	1	19
12	32	6	4	0	0	0	0	0	0	0
13	32	6	4	0	2	0	3	0	0	0
14	32	6	4	0	0	0	0	0	0	0
15	32	6	4	0	1	1	1	0	0	0
16	58	4	6	16	0	0	1	0	0	0
17	32	6	4	0	0	0	3	0	0	0
18	58	6	4	20	0	0	1	0	0	0
19	58	4	6	19	0	0	1	0	0	0
20	57	4	6	17	1	0	3	0	0	0
21	32	6	4	0	3	0	0	0	0	0
22	57	6	4	24	1	0	0	0	0	0
23	32	6	6	17	2	1	0	0	0	0
24	32	6	4	0	2	0	3	0	0	0
25	58	6	4	30	0	0	0	0	0	0
26	32	6	4	0	0	0	0	0	1	19
27	32	6	4	0	0	0	0	0	0	0
28	32	6	4	0	0	1	3	0	0	0
29	32	6	6	17	0	0	0	0	0	0
30	60	1	4	0	0	0	0	1	0	0
31	32	6	6	11	0	0	0	0	0	0
32	56	0	4	0	0	0	0	0	1	20
33	56	0	4	0	0	0	0	0	0	0
34	56	0	4	0	0	0	0	0	0	0
35	56	0	4	0	0	0	0	0	0	0
36	56	0	8	0	0	0	0	2	0	0
37	56	0	4	0	0	0	0	1	0	0
38	56	0	4	0	0	0	0	0	0	0
39	56	0	4	0	0	0	0	0	0	0
40	60	0	5	0	0	0	0	0	0	0
41	56	0	4	0	0	0	0	0	0	0
42	56	0	4	0	0	0	0	0	0	0
43	56	0	4	0	0	0	0	0	0	0
44	56	0	6	0	0	0	0	0	0	0
45	32	6	10	11	0	0	0	2	0	0
46	32	6	4	0	0	0	0	0	1	19
47	32	6	4	0	0	0	0	0	0	0
48	32	6	4	0	0	0	0	0	1	18
49	32	6	4	0	0	0	0	0	0	0
50	32	0	10	55	0	0	0	0	0	0
51	32	0	10	55	0	0	0	0	0	0
52	32	6	6	3	0	0	0	0	0	0
53	56	0	4	0	0	0	0	0	0	0
54	32	6	6	0	0	0	0	0	0	0
55	32	6	4	0	0	0	0	0	0	0
56	56	0	4	0	2	0	3	0	0	0
57	57	6	4	61	1	0	0	0	0	0
58	57	6	4	60	1	0	0	0	0	0
59	57	4	6	59	1	0	0	0	0	0
60	56	0	4	0	0	0	0	0	0	0
61	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

APM-INSTRUCTIONS DEFINED

MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.
0	7	5	1	0	0
1	2	4	1	0	0
2	2	4	1	0	0
3	2	4	1	0	0
4	2	4	1	0	0
5	2	4	1	0	0
6	2	4	1	0	0
7	2	4	1	0	0
8	2	4	1	0	0
9	2	4	1	0	0
10	2	4	1	0	0
11	2	4	1	0	0
12	2	4	1	0	0
13	2	4	1	0	0
14	2	4	1	0	0
15	2	0	3	0	13
16	1	0	3	14	13
17	2	4	1	0	0
18	2	0	3	0	13
19	1	0	3	14	13
20	2	4	1	0	0
21	2	4	1	0	0
22	2	4	1	0	0
23	2	4	1	0	0
24	2	4	1	0	0
25	2	4	1	0	0
26	2	4	1	0	0
27	2	4	1	0	0
28	2	4	1	0	0
29	2	4	1	0	0
30	0	0	0	15	0
31	2	4	1	0	0
32	7	5	1	0	0
33	7	5	1	0	0
34	7	5	1	0	0
35	7	4	0	0	0
36	0	[illegible]	0	0	0
37	0	0	0	0	0
38	2	[illegible]	1	0	0
39	2	0	1	0	0
40	2	0	1	0	0
41	7	5	1	0	0
42	7	5	1	0	0
43	7	[illegible]	1	0	0
44	7	[illegible]	1	0	0
45	[illegible]	[illegible]	1	0	0
46	[illegible]	[illegible]	1	0	0
47	2	[illegible]	1	0	0
48	2	4	1	0	0
49	2	4	1	0	0
50	2	4	1	0	0
51	0	0	0	14	0
52	0	0	0	14	0
53	2	0	1	0	0
54	7	5	0	0	0
55	7	5	1	0	0
56	7	5	1	0	0
57	2	0	1	0	0
58	7	5	1	0	0
59	7	5	1	0	0
60	2	0	1	0	0
61	7	5	1	0	0

APB-INSTRUCTIONS DEFINED

MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT
0	7	5	1	0	0	0
1	4	0	3	5	4	0
2	2	4	1	0	0	0
3	4	0	1	4	0	0
4	2	4	1	0	0	0
5	2	4	1	0	0	0
6	1	1	3	8	4	0
7	4	0	1	13	0	0
8	2	4	1	0	0	0
9	4	0	3	15	0	0
10	2	4	1	0	0	0
11	4	0	1	14	0	0
12	2	4	1	0	0	0
13	2	0	3	0	3	0
14	4	0	3	3	1	0
15	4	0	3	3	2	0
16	1	0	3	9	2	0
17	1	0	3	12	1	0
18	4	0	3	1	2	0
19	1	0	3	9	2	0
20	2	4	1	0	0	0
21	0	0	0	12	0	0
22	4	0	3	3	1	0
23	1	1	3	12	1	0
24	1	1	3	8	10	0
25	2	4	1	0	0	0
26	4	0	1	10	0	0
27	2	4	1	0	0	0
28	2	0	3	0	3	0
29	0	1	3	12	1	0
30	4	0	3	14	10	0
31	0	1	0	11	0	0
32	7	0	1	0	0	0
33	7	5	1	0	0	0
34	7	5	1	0	0	0
35	7	5	1	0	0	0
36	7	5	1	0	0	0
37	7	5	1	0	0	0
38	7	5	1	0	0	0
39	7	5	1	0	0	0
40	7	5	1	0	0	0
41	7	5	1	0	0	0
42	7	5	1	0	0	0
43	7	5	1	0	0	0
44	7	5	1	0	0	0
45	2	4	1	0	0	0
46	4	0	1	7	0	0
47	2	4	1	0	0	0
48	4	0	1	6	0	0
49	2	4	1	0	0	0
50	0	1	0	11	0	0
51	7	5	1	0	0	0
52	1	0	0	8	3	0
53	7	5	0	0	0	0
54	7	5	1	0	0	0
55	1	1	3	12	11	0
56	0	0	0	11	0	0
57	0	1	0	11	0	0
58	2	0	1	0	0	0
59	0	0	0	12	0	0
60	0	0	0	12	0	0
61	2	0	3	0	3	0
62	0	1	0	11	0	0
63	1	0	3	[illegible]	11	0

ARITHMETICAL INSTRUCTIONS DEFINED

MEM-LOC.	M1A	M1B	M2A	M2B	M3A	M3B	M4A	M4B	SM1	SM2	SM3	SM4	M12	M34
0	0	0	0	0	0	0	0	0	0	0	0	0	15	15
1	4	3	4	3	4	3	4	3	0	0	0	0	12	12
2	4	3	4	3	4	3	4	3	0	0	0	0	12	12
3	4	3	4	3	4	3	4	3	0	0	0	0	12	12
4	4	3	4	3	4	3	4	3	0	0	0	0	12	12
5	4	3	4	3	4	3	4	3	0	0	0	0	12	12
6	4	3	4	3	4	3	4	3	0	0	0	0	12	12
7	4	3	4	3	4	3	4	3	0	0	0	0	12	12
8	4	3	4	3	4	3	4	3	0	0	0	0	12	12
9	4	3	4	3	4	3	4	3	0	0	0	0	12	12
10	4	3	4	3	4	3	4	3	0	0	0	0	12	12
11	4	3	4	3	4	3	4	3	0	0	0	0	12	12
12	4	3	4	3	4	3	4	3	0	0	0	0	12	12
13	0	0	1	1	1	0	0	1	1	1	1	1	12	12
14	4	3	4	3	4	3	4	3	0	0	0	0	12	12
15	0	0	1	1	1	0	0	1	2	2	2	2	9	6
16	0	0	1	1	1	0	0	1	2	2	2	2	9	6
17	4	3	4	3	4	3	4	3	0	0	0	0	12	12
18	0	0	1	1	1	0	0	1	2	2	2	2	9	6
19	0	0	1	1	1	0	0	1	2	2	2	2	9	6
20	4	3	4	3	4	3	4	3	0	0	0	0	12	12
21	0	0	1	1	1	0	0	1	1	1	1	1	12	12
22	4	3	4	3	4	3	4	3	0	0	0	0	12	12
23	4	3	4	3	4	3	4	3	0	0	0	0	12	12
24	4	3	4	3	4	3	4	3	0	0	0	0	12	12
25	4	3	4	3	4	3	4	3	0	0	0	0	12	12
26	4	3	4	3	4	3	4	3	0	0	0	0	12	12
27	4	3	4	3	4	3	4	3	0	0	0	0	12	12
28	4	3	4	3	4	3	4	3	0	0	0	0	12	12
29	4	3	4	3	4	3	4	3	0	0	0	0	12	12
30	4	3	4	3	4	3	4	3	0	0	0	0	12	12
31	4	3	4	3	4	3	4	3	0	0	0	0	12	12
32	0	0	0	0	0	0	0	0	0	0	0	0	15	15
33	0	0	0	0	0	0	0	0	0	0	0	0	15	15
34	0	0	0	0	0	0	0	0	0	0	0	0	15	15
35	0	0	0	0	0	0	0	0	0	0	0	0	15	15
36	0	0	0	0	0	0	0	0	0	0	0	0	15	15
37	0	0	0	0	0	0	0	0	0	0	0	0	15	15
38	0	0	0	0	0	0	0	0	0	0	0	0	15	15
39	0	0	0	0	0	0	0	0	0	0	0	0	15	15
40	0	0	0	0	0	0	0	0	0	0	0	0	15	15
41	0	0	0	0	0	0	0	0	0	0	0	0	15	15
42	0	0	0	0	0	0	0	0	0	0	0	0	15	15
43	0	0	0	0	0	0	0	0	0	0	0	0	15	15
44	0	0	0	0	0	0	0	0	0	0	0	0	15	15
45	4	3	4	3	4	3	4	3	0	0	0	0	12	12
46	4	3	4	3	4	3	4	3	0	0	0	0	12	12
47	4	3	4	3	4	3	4	3	0	0	0	0	12	12
48	4	3	4	3	4	3	4	3	0	0	0	0	12	12
49	4	3	4	3	4	3	4	3	0	0	0	0	12	12
50	4	3	4	3	4	3	4	3	0	0	0	0	12	12
51	4	3	4	3	4	3	4	3	0	0	0	0	12	12
52	4	3	4	3	4	3	4	3	0	0	0	0	12	12
53	0	0	0	0	0	0	0	0	0	0	0	0	12	12
54	0	0	0	0	0	0	0	0	0	0	0	0	15	15
55	0	0	0	0	0	0	0	0	0	0	0	0	15	15
56	0	0	0	0	0	0	0	0	0	0	0	0	15	15
57	0	0	1	1	4	0	4	1	3	3	3	3	9	9
58	0	0	0	0	0	0	0	0	3	3	3	3	6	6
59	0	0	1	1	4	0	4	1	3	3	3	3	9	9
60	0	0	1	1	4	0	4	1	3	3	3	3	9	9
61	0	0	0	0	0	0	0	0	3	3	3	3	6	6
62	0	0	0	0	0	0	0	0	3	3	3	3	6	6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0	15	15

ACCUMULATOR INSTRUCTIONS DEFINED

MEM-LOC.	STROBE	I/O WRITE	READ	CLEAR1	SET1	CLEAR2	SET2
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	1	0	0	0
14	0	0	0	0	0	0	0
15	1	1	1	0	0	0	0
16	1	1	1	0	0	0	0
17	0	0	0	0	1	0	0
18	1	1	1	0	0	0	0
19	1	1	1	0	0	0	0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0
44	0	0	0	0	0	1	0
45	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0
53	1	1	1	0	0	0	0
54	0	0	0	0	0	0	1
55	0	0	0	0	0	0	0
56	1	0	0	1	0	0	0
57	1	0	1	0	0	0	0
58	1	0	0	0	0	0	0
59	1	0	0	0	0	0	0
60	1	1	0	0	1	0	0
61	1	0	0	0	0	0	0
62	1	1	0	0	0	0	0
[illegible]	0	0	0	0	0	0	0

I/O INSTRUCTIONS DEFINED

MEM-LOC.	SETF	CLEARF	SELECT BUF.ADDR.	STROBE I-REG.	ENABLE EDB	ENABLE EAB
0	0	0	0	0	0	0
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	0	0	0
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	0	0	0
35	0	0	0	0	0	0
36	0	0	0	0	0	0
37	0	0	0	0	0	0
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
57	0	0	0	0	0	0
58	0	0	0	0	0	0
59	0	0	0	0	0	0
60	0	0	0	0	0	0
61	0	0	0	0	0	0
62	0	0	0	0	0	0

OUTPUT-TRANSFER INSTRUCTIONS DEFINED

MEM-LOC.	TRANSFER	INHIBIT CLOCK	DATA-READY	TRANSFER-CODE	SOURCE
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0	0	0	0
32	0	0	0	0	0
33	0	0	0	0	0
34	1	0	0	0	0
35	1	1	1	0	0
36	1	1	1	1	0
37	1	1	1	3	0
38	1	1	1	2	0
39	1	1	1	5	0
40	1	1	1	4	0
41	1	0	0	0	0
42	1	0	0	0	0
43	1	0	0	0	0
44	1	0	0	0	0
45	0	0	0	0	0
46	0	0	0	0	0
47	0	0	0	0	0
48	0	0	0	0	0
49	0	0	0	0	0
50	0	0	0	0	0
51	0	0	0	0	0
52	0	0	0	0	0
53	0	0	0	0	0
54	0	0	0	0	0
55	0	0	0	0	0
56	0	0	0	0	0
57	0	0	0	0	0
58	0	0	0	0	0
59	0	0	0	0	0
60	0	0	0	0	0
61	0	0	0	0	0
62	0	0	0	0	0
63	0	0	0	0	0

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