

**EISCAT
TECHNICAL
NOTE**

EISCAT DIGITAL CORRELATOR

TEST MANUAL

**KIRUNA
Sweden**

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1. INTRODUCTION

During 1978 a prototype of EISCAT digital correlator has been designed and constructed. This report gives a summary of the correlator together with a description of test structures. The tests include a complete dynamic check of the correlator module at system level. It is assumed that the different circuit cards have been "debugged" and tested separately, preventing major logic hardware faults.

For optimum test possibilities and hardware diagnostics, several test options have been considered, and the used test structures are given in Chapter 2. The hardware complexity of the correlator system requires extensive use of the radar-site computer NORD-10 (host computer for the correlator system) together with ordinary facilities like logic analyzers and test probes.

The correlator testing is divided into two levels: Hardware tests, described in Chapter 3, and system tests, Chapter 4. Hardware tests require use of 32-channel analyzer for measurements on output from different internal processors of the correlator. The system tests make use of the computer DMA-channel with hardware diagnostics by display/print. Also computerized detection is included, particularly for long-term stability tests. Another option which can be used is comparison of correlator data with results from a software simulator.

A large number of correlator test-program (microprograms in machine language) have been constructed during the prototype tests. These can be easily loaded into the correlator with interactive use of the CORRSIM program (Ref.). The created library of the testprograms is described in Chapter 5.

The test-structures used for the prototype should also be used for the production of correlator modules. The computerized test measurements can also be a start-point for future maintenance/error-detection schemes when the correlator is an element of the EISCAT radar system.

2. MEASUREMENT SCHEMES FOR PROTOTYPE TESTING

In Figure 1 the used measurement schemes for testing the prototype are sketched.. Several options have been included so it has been possible to adapt different testing procedures to the different internal hardware functions. In order to make full use of the testsystem capabilities, the user must have detailed knowledge about the construction of the correlator and to some extent also the use of the CORRSIM program. This can be found in ref. 1-3.

This report describes system tests, which have been divided into two groups: hardware tests with use of logic state analyzer and analog oscilloscope and system tests with computerized handling of correlator data. By use of fixed testprograms from the CORRSIM file system, the hardware/system tests can be made standardized and repetitive. The correlator has a built-in data-memory, which simulates the buffer-memory at the data input, and the fixed data input enables standardized and repetitive tests of the correlator arithemtical functions (data processing unit) and the possibility of datatable comparison with values generated from software simulation.

When analog/digital oscilloscope displays are given in this report a listing of the used probing points (mainly on correlator back-wiring) is attached.

A measurement station for testing the correlator has been established at the Ramfjordmoen radar site. A photo of the measurements equipment is given in Figure 2.

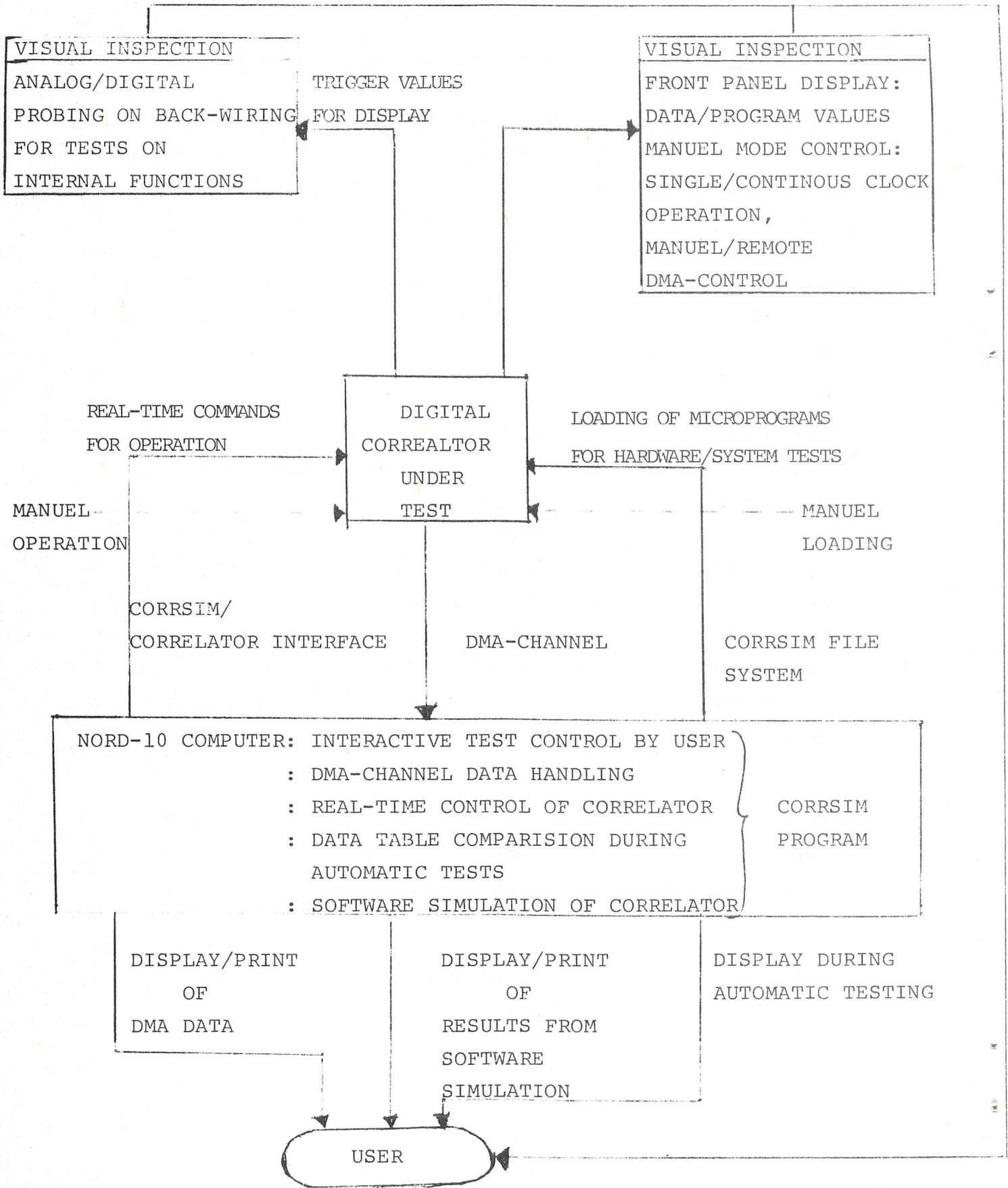


FIGURE 1. MEASUREMENT OPTIONS FOR COMPUTERIZED SYSTEM TESTING:

3. HARDWARE TESTS

The hardware tests are divided into two groups: preparation and subsystem tests. Preparation tests include fundamental functions for system operation and the hardware section for loading correlator from the CAMAC output module. Subsystem tests include testing the different function-modules of the correlator and testprograms have been prepared on a file-system for loading testparameters to the correlator by the CORESIM program.

3.1 Preparation tests.

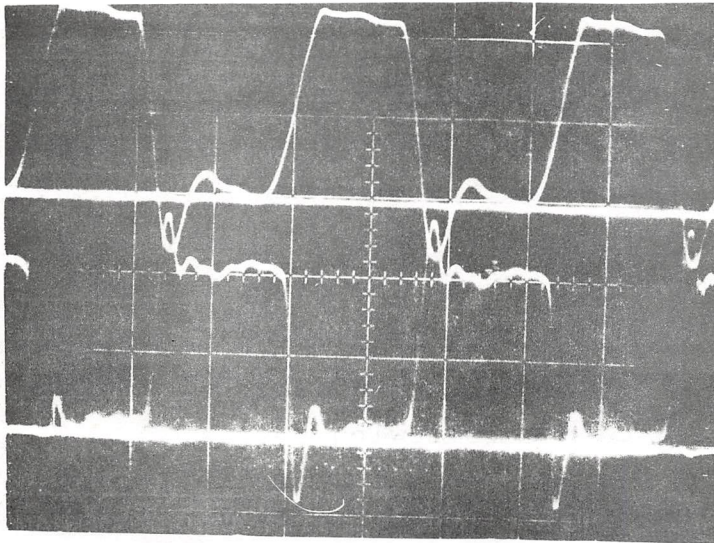
3.1.1 System clock.

The internal 6 MHz clock-signal is generated from the crystal clock-oscillator on card-module CM1.

Clock-signal distribution on back-wiring:

<u>SIGNAL NAME</u>	<u>CARD-MODULE, TERM</u>	<u>TYPE</u>
CLOCK	CM1, 1A32	SOURCE
CLOCK	CM2, 1A32	SINK
	CM4, 1A32	SINK
	CM5, 1A32	SINK
	LCi, 1A32	SINK
<hr/>		
CLOCK	CM4, 1B31	SOURCE
<hr/>		
CLOCK	CM3, 1B31	SINK

In manuel mode of operation and clock-function CONTINUOUS on front-panel, the clock-signals are always active when the correlator is in stop-mode. In Figure 3, the two source-signals for clock operation are shown.



CLOCK
terminal CM1, 1A32

CLOCK,
terminal CM4, 1B31

Figure 3. System clock. x=50 nsec/div. y=3 v/div.

3.1.2 MASTER RESET.

Source for the signal is either the frontpanel (manuel status) or computer through the CAMAC output register B, bit 5 (remote status). Note that the signal on the CAMAC-bus is active at low level, so the MASTER RESET signal is continuous active when the power on the CAMAC create is turned off. This also implies that when the CAMAC cables are connected on the rear side the correlator can be made operative only when the create power is turned on (both for manual/remote status).

MASTER RESET SIGNAL DISTRIBUTION ON BACK-WIRING:

<u>SIGNAL NAME</u>	<u>CARD-MODULE, TERM</u>	<u>TYPE</u>	<u>ACTIVE LEVEL</u>
MASTER RESET	CM1, 1A12 (INPUT from canal)	SINK	LOW
MASTER RESET	CM1, 1A13	SOURCE	LOW DISTRIB.TO OTHER CARDS
MASTER RESET	CM2, 1A31	SINK	LOW
MASTER RESET	CM4, 2B6	SINK	LOW
MASTER RESET	CM5, 1C31	SINK	LOW
ZERO PC	CM4, 2B7	SOURCE	LOW
ZERO PC	CM3, 2B6	SINK	LOW

A related signal from the MASTER RESET is the signal ZERO PC generated from cardmodule CM4 and received at CM3 for resetting the program-counter. The actual program-counter value can be displayed at the front panel in manual by setting the display-select to "front-panel" and the display code: S210 = 111 (testword 2): The program-counter is displayed by bits 14-9,):LSB. The distributed MASTER RESET signal in the correlator should have the following levels:

<u>SIGNAL NAME</u>	<u>TERMINAL</u>	<u>STATE</u>	<u>LEVEL (volts)</u>
MASTER RESET	CM1, 1A13	LOW	0.30
		HIGH	3.80
ZERO PC	CM4, 2B7	LOW	0.30
		HIGH	3.80

3.1.3 Input loading from frontpanel/CAMAC.

Input loading from the frontpanel (manual status/continuous clock): Visual check on load-sequence can be obtained by doing the following:

- a) set up a valid address, subaddress on the front-panel,
- b) press "address-load" and the response should be active LED for the front-panel as a source,
- c) by setting the display-select to testword 2, the subaddress code is given by the PC-value bits,
- d) press "data-load" and the LED indicator should return to inactive state and PC-value to zero.

This procedure tests the hardware for the following loading on cardmodule CM2, which is also the source for the PC-value during loading. During loading the main status "RUN" should not be active.

The address-load operation sets the following signals at the backwiring:

SIGNAL NAME	SOURCE- TERMINAL	ACTIVE LEVEL	SINK- TERMINAL	FUNCTION
ENABLE LOAD	CM2, 1C23	HIGH	CM, 1C23	DISCONNECT μ -SEQUENCER AS SOURCE FOR INTERNAL ADDRESS-BUS
			CM5	RESETS ALL INSTRUCTION-REGISTERS AND DISABLES THE PC SHIFT-REGISTER-CHAIN. ENABLES THE APM PROCESSOR FOR LOADING ON STROBE-SIGNAL
ENABLE LOAD CM4	CM2, 2C5	LOW	CM4, 2C5	DISABLES "CORRELATOR RUN" SIGNAL (2C9), AND ENABLES LOAD OF RAM-MODULES 0,1 AND 2.
ZERO PC	CM4, 2B7	LOW	CM3, 2B6	SETS PC-VALUE TO ZERO
CARRY μ -SEQUENCER	CM4, 2B8	LOW	CM3, 2B8	DISABLES CARRY TO MICRO SEQUENCER.
ADDRESS LOAD INDICATION	C2, 2C6	HIGH	CANAL A- REG. EXENTRAL x-RESPONSE	DISABLES x-RESPONSE ON CAMAC A-REGISTER OUTPUT FOR INDICATION OF LOAD-ADDRESS.

The address-load operation activates the following buslines for distribution of the subaddress (6 bits):

BUS NAME	SOURCE-TERMINALS	SINK TERMINALS	FUNCTION
ADDRESS-LOAD I	CM2, 1A27, 28, 19, 20, 21, 22, 81 (LSB)	CM3, 1A27, 28, 19, 20, 21, 22 (LSB)	CONNECT LOAD-ADDRESS TO RAM-MODULES 0.1 AND 2.
		CM5, 1A27, 28, 19, 20, 21, 22 (LSB)	CONNECT LOAD-ADDRESS TO RAM-MODULE 3 (8LSB BITS)
ADDRESS-LOAD II	CM2, 2C9, 10, 11, 12, 13, 14 (LSB)	CM5, 2C1, 2, 3, 4, 5, 6 (LSB)	CONNECT LOAD-ADDRESS TO RAM-MODULE 3

BUS NAME	SOURCE-TERMINALS	SINK-TERMINALS	FUNCTION
			(8MSB BITS) RAM-MODULE 4 RAM-MODULE 5
ADDRESS-LOAD III	CM4, 2B10, 11, 12, 13, 14, 15 (LSB)	CM5, 2C7, 8, 9, 10, 11, 12 (LSB)	CONNECT LOAD-ADDRESS TO MODULE 6 AND 7 (8LSB BITS)
ADDRESS-LOAD IV	CM4, 2B16, 17, 18, 19, 20, 21 (LSB)	CM5, 2C13, 14, 15, 16, 17 (LSB)	CONNECT LOAD-ADDRESS TO RAM-MODULE 3 (8MSB BITS) AND 7 (8MSB BITS)

TEST ON ADDRESS DECODING FOR THE DATA-FILED LOADING:

Make the following connections with the logic state analyzer:

Channel B connections	Card-terminal	Signal name
bit 0	CM2, 1C18	INTERNAL DATA-BUS, LSB BIT
bit 1	CM2, 1C17	INTERNAL DATA-BUS, BIT 1
.	.	.
.	.	.
.	.	.
.	.	.
bit 15	CM2, 1C3	INTERNAL DATA-BUS, MSB BIT
qualifier Qo	pin 12 on D-H (CM2)	DATA STROBE ENABLE
clock-input (↑)	CM2, 1A32	SYSTEM CLOCK

Channel A connections	Card-terminal	Signal name
bit 0	CM2, 1C26	SAR REGISTER STROBE, strobe at ↑
bit 1	CM2, 1C19	BAR REGISTER STROBE, strobe at ↑
bit 2	CM2, 1C24	STROBE DATA I-REGISTER, APB, strobe at
bit 3	CM2, 1A29	LOAD REGISTER-STACK APB, load on high level
bit 4	CM2, 1A30	LOAD REGISTER-STACK APM, load on high level
bit 5	CM2, 1C20	STROBE LCR1, strobe at ↑
bit 6	CM2, 1C21	STROBE LCR2, strobe at ↑
bit 7	CM2, 1C22	STROBE LCR3, strobe at ↑
bit 8	CM2, 1A22	SUBADDRESS, LSB BIT
bit 9	CM2, 1A21	- " -, bit 1
bit 10	CM2, 1A20	- " -, bit 2
bit 11	CM2, 1A19	- " -, bit 3

<u>Channel A connections</u>	<u>Card-terminal</u>	<u>Signal name</u>
bit 12	CM2,1A28	SUBADDRESS, bit 4
bit 13	CM2,1A27	- " - , MSB bit
qualifier Qo	pin 5 on D-ff (CM2)	DATA STROBE ENABLE
clock-input	CM2, 1A32	SYSTEM CLOCK

Set qualiter Qo to trigger on high-level.

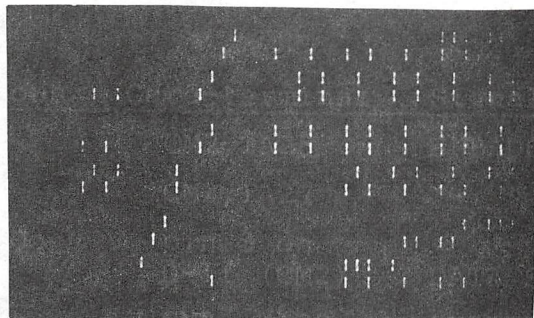
Test-result on loading registers in data-field:

REGISTERS IN DATAFIELD DEFINED

START-ADDR. REGISTER = 77
D-REGISTER, APB = 125252
I-REGISTER, APB = 005252
REGISTER FOR LOOP-COUNTER 1 = 0017
REGISTER FOR LOOP-COUNTER 2 = 0360
REGISTER FOR LOOP-COUNTER 3 = 7400

Display:

APB-STACK:	APM-STACK:
REG.05 = 052525	REG.05 = 2525
REG.12 = 125252	REG.12 = 5252



CHANNEL A LSB CHANNEL B LSB

Note that the data I-register APB should be loaded at the end of the loading sequence, because the loading of the APB processor uses the data I-register in entering data to the register-stack, i.e. the loading of the processor requires two-load cycles, one for loading the I-register and one for transferring I-register content to the stack. This procedure holds only for the APB processor.

Test-result on loading the APM-processor:

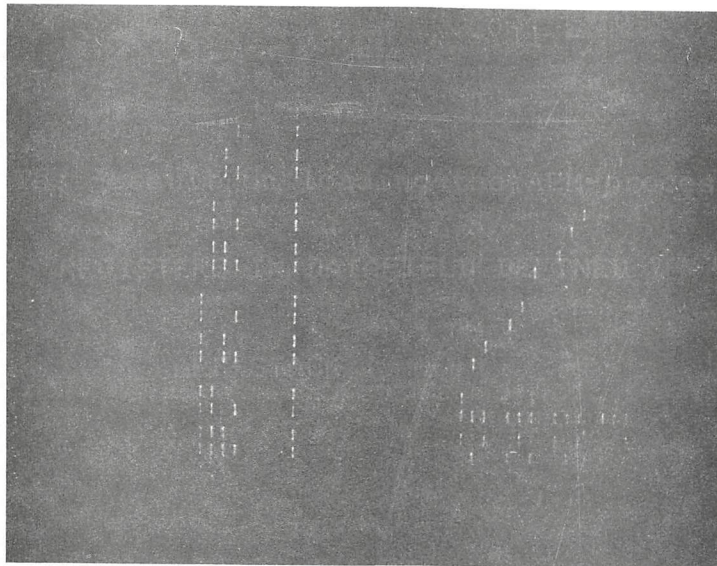
REGISTERS IN DATAFIELD DEFINED

APB-STACK :

AFM-STACK :

REG.00=0000
REG.01=0001
REG.02=0002
REG.03=0004
REG.04=0010
REG.05=0020
REG.06=0040
REG.07=0100
REG.10=0200
REG.11=0400
REG.12=1000
REG.13=2000
REG.14=4000
REG.15=7777
REG.16=5252
REG.17=2525

Display output:



TEST ON ADDRESS DECODING FOR THE PROGRAM-FIELD LOADING:

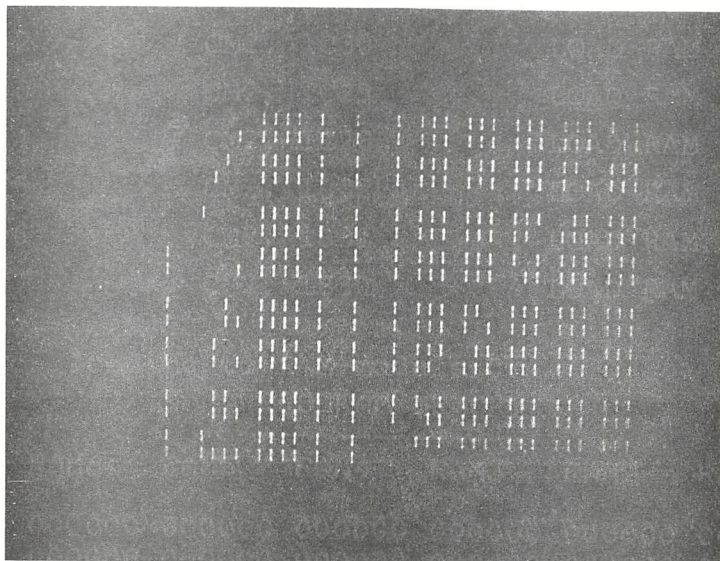
Modifications on channel A connections:

Channel A	Card-terminal	Signal name
bit 0	CM2, 1C32	LOAD RAM 0, active on high level
bit 1	CM2, 1C31	LOAD RAM 1, high
bit 2	CM2, 1C30	LOAD RAM 2, high
bit 3	CM2, 1C29	LOAD RAM 3, active on low level
bit 4	CM2, 1C28	LOAD RAM 4, - " -
bit 5	CM2, 1B32	LOAD RAM 5, - " -
bit 6	CM2, 1B31	LOAD RAM 6, - " -
bit 7	CM2, 1B30	LOAD RAM 7, - " -

Test on loading to RAM-module 0:

PROGRAM MEMORY

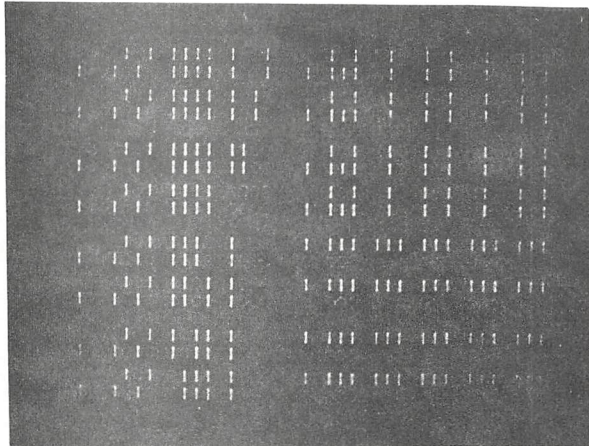
MEM.ADD.	RAM7	RAM6	RAM5	RAM4	RAM3	RAM2	RAM1	RAM0
00	000000	000000	000000	000000	000000	000000	000000	000002
01	000000	000000	000000	000000	000000	000000	000000	000004
02	000000	000000	000000	000000	000000	000000	000000	000010
04	000000	000000	000000	000000	000000	000000	000000	000020
10	000000	000000	000000	000000	000000	000000	000000	000040
20	000000	000000	000000	000000	000000	000000	000000	000100
40	000000	000000	000000	000000	000000	000000	000000	000200
41	000000	000000	000000	000000	000000	000000	000000	000400
42	000000	000000	000000	000000	000000	000000	000000	001000
43	000000	000000	000000	000000	000000	000000	000000	002000
44	000000	000000	000000	000000	000000	000000	000000	004000
45	000000	000000	000000	000000	000000	000000	000000	010000
46	000000	000000	000000	000000	000000	000000	000000	020000
47	000000	000000	000000	000000	000000	000000	000000	040000
50	000000	000000	000000	000000	000000	000000	000000	100000
77	000000	000000	000000	000000	000000	000000	000000	177777



Test on loading to all RAM-modules:

PROGRAM MEMORY

	MEM.ADD.	RAM7	RAM6	RAM5	RAM4	RAM3	RAM2	RAM1	RAM0
	25	000000	000000	000000	000000	125252	125252	125252	125252
Display:	52	177777	177777	177777	177777	005252	005252	005252	005252



Note that the complement value of the data should be loaded to the RAM memories.

3.1.4 STATUS WORD LOADING

The programmable bits of the statusword (see instruction manual) can be tested by visual inspection of the LED indicators on the frontpanel and in manual operation by display-code 000. The programmable bits of the statusword activate the following signals at the back-wiring.

BIT NO.	LEVEL	FUNCTION	SOURCE-TERMINAL	LEVEL	SINK-TERMINAL (S)
3	0	RAM SELECTED	C1, 1A31	INVERTED	CM3, 1C25
	1	ROM SELECTED			CM5, 1C25
4	0	BUFFER MEM. SELECTED			
	1	TEST MEM. SELECTED	C1, 2A1	TRUE	CM4, 2A30
§	0	START EXPERIMENT			
	1	CONTINUE EXPERIMENT	C1, 2A3	TRUE	CM5, 1C32

3.2. TESTS ON THE INTERNAL μ -PROGRAM EXECUTION

3.2.1. TESTS ON μ -PROGRAM INSTRUCTION WORD AND START SEQUENCE

Analyzer connections used:

<u>Channel B</u>	<u>Card terminal</u>	<u>Signal name</u>
bit 0	CM4,2A16	Code A, bit 0 (LSB)
1	CM4,2A15	Code A, bit 1
2	CM4,2A14	Code A, bit 2
3	CM4,2A13	Code A, bit 3 (MSB)
4	CM4,2A12	Code B, bit 0 (LSB)
5	CM4,2A11	1
6	CM4,2A10	2
7	CM4,2A9	3 (MSB)
8	CM4,2A8	Condition code, bit 0 (LSB)
9	CM4,2A7	1
10	CM4,2A6	2
11	CM4,2A5	3
12	CM4,2A4	4
13	CM4,2A3	5 (MSB)
14	CM4,2C4	START COMPUTE
15	CM3,1A32	START TRANSFER
clock input (1)	CM4,1A32	SYSTEM CLOCK
<u>Channel A</u>	<u>Card terminal</u>	<u>Signal name</u>
bit 0	CM3,1A22	Program-counter, bit 0 (LSB)
1	CM3,1A21	1
2	CM3,1A20	2
3	CM3,1A19	3
4	CM3,1A28	4
5	CM3,1A27	5 (MSB)
6	CM4,2B2	Code selected, bit 0 (LSB)
7	CM4,2B1	1
8	CM4,2B3	2
9	CM4,2B4	3 (MSB)
10	CM4,2C9	CORRELATOR RUN
11	CM4,2B8	CARRY μ -SEQUENCER
12	CM4,2B5	GOTO 77
clock input (4)	CM5,1A32	SYSTEM CLOCK

After the power is turned on and MASTER-RESET has been activated, the "code selected", bits 9-6 on channel A, should have the value 4_8 and "carry μ -sequence" low. The test begins with loading SAR=0, and the individual bits of "condition-code", "code A" and "code B" can be tested in remote status by use of the program CORR SIM (RAM-memory selected).

Test on START-COMPUTE:

Load OUT-INSTRUCTION=0 in all program-locations and load the following μ -program:

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004000
START-ADDR. REGISTER = 01

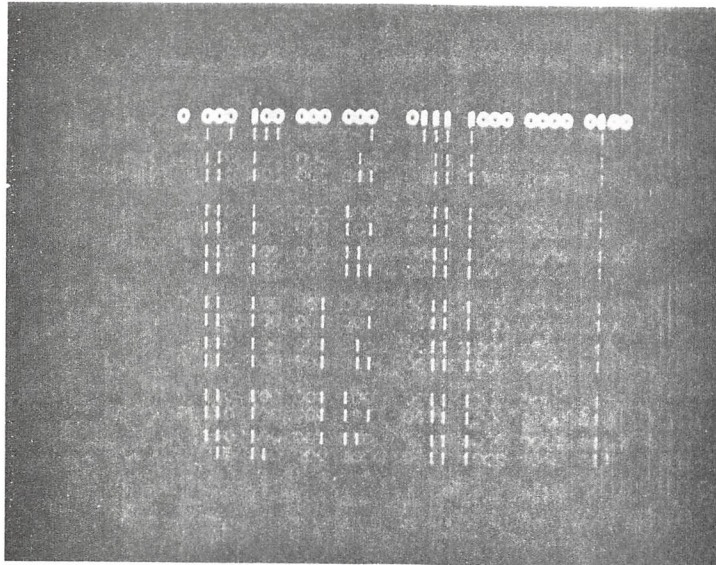
C*LFS:PRO

GIVE LOWER,UPPER, VALUE IN MEMORY FOR DISPLAY:

PROGRAM-INSTRUCTIONS DEFINED

MEM-LOC.	COND.	CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
00	70	00	04	00	00	0	0	0	0	0	00
01	70	00	04	00	00	0	0	0	0	0	00
02	70	00	04	00	00	0	0	0	0	0	00
03	70	00	04	00	00	0	0	0	0	0	00
04	70	00	04	00	00	0	0	0	0	0	00
05	70	00	04	00	00	0	0	0	0	0	00
06	70	00	04	00	00	0	0	0	0	0	00
07	70	00	04	00	00	0	0	0	0	0	00
10	70	00	04	00	00	0	0	0	0	0	00
11	70	00	04	00	00	0	0	0	0	0	00
12	70	00	04	00	00	0	0	0	0	0	00
13	70	00	04	00	00	0	0	0	0	0	00
14	70	00	04	00	00	0	0	0	0	0	00
15	70	00	04	00	00	0	0	0	0	0	00
16	70	00	06	00	00	0	0	0	0	0	00

The program starts at PC = 1 and a continue-statement is active up to PC=16, then a direct jump to PC is given. This program-routine should give the following display, when triggered on active high level for bit 14, channel B (START COMPUTE).



Test on CONTINUE-statement:

Load all locations 0-75 with a continue-statement and location 76 with a jump to zero.

- a) Trace the program-counter when SAR=1
- b) Repeat a) for SAR=2,4,10,20,40,25 and 52.

Test on JUMP-statement:

REGISTERS IN DATAFIELD DEFINED

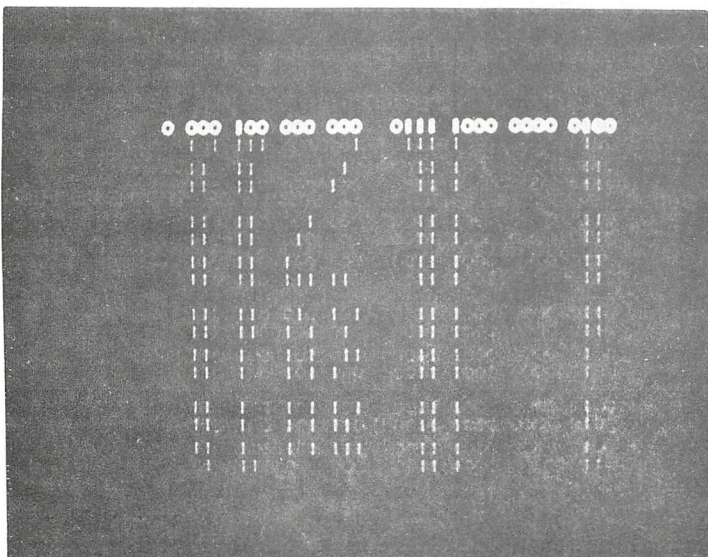
STATUS-REGISTER = 004000
 START-ADDR. REGISTER = 01

C*LF

GIVE LOWER,UPPER, VALUE IN MEMORY FOR DISPLAY:
 PROGRAM MEMORY

MEM.ADD.	RAM7	RAM6	RAM5	RAM4	RAM3	RAM2	RAM1	RAM0
00	000000	000000	000000	000000	000000	000000	070010	000000
01	000000	000000	000000	000000	000000	004000	070014	000000
02	000000	000000	000000	000000	000000	010000	070014	000000
04	000000	000000	000000	000000	000000	020000	070014	000000
10	000000	000000	000000	000000	000000	040000	070014	000000
20	000000	000000	000000	000000	000000	100000	070014	000000
25	000000	000000	000000	000000	000000	124000	070014	000000
40	000000	000000	000000	000000	000000	174000	070014	000000
52	000000	000000	000000	000000	000000	000000	070010	000000
53	000000	000000	000000	000000	000000	000000	070010	000000
54	000000	000000	000000	000000	000000	000000	070010	000000
55	000000	000000	000000	000000	000000	000000	070010	000000
56	000000	000000	000000	000000	000000	000000	070010	000000
57	000000	000000	000000	000000	000000	000000	070014	000000
76	000000	000000	000000	000000	000000	052000	070014	000000

Display:



3.2.2 FIXED-FILE PROGRAM FOR TESTING THE μ -PROGRAM EXECUTION

PROGRAM NAME:

TESTPROGRAM H1: TESTS ON INTERNAL PROGRAM EXECUTION

See chapter for test-program summary for description of test-structure. On the following page the program instructions are listed. If the program-counter is reaching statement 67 and a direct jump to 0 is made, the tested μ -program instructions have been executed without hardware error.

The test-program has been run through the CORRSIM software simulator for testing the mapping of the internal program counter and the simulator listing is given on the following pages. The program counter mapping can be found in the column under the "program location" heading. The clock-interval is given in the left column. Testing performed on the physical correlator system is done at the same test-points as given in section 3.2.1. The test-results are given on the following pages.

Test-program H1 listing.

PROGRAM-INSTRUCTIONS DEFINED											
MEM-LOC.	COND.	CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
00	70	00	04	00	00	0	0	0	0	0	00
01	70	00	04	00	00	2	0	3	2	0	00
02	70	00	04	00	00	0	0	0	1	0	00
03	74	04	06	00	00	0	0	0	3	0	00
04	54	04	06	00	00	0	0	0	0	0	00
05	71	06	04	00	00	0	0	0	0	0	00
06	72	06	04	00	00	0	0	0	0	0	00
07	74	06	04	00	00	0	0	0	0	0	00
10	73	06	04	00	00	0	0	0	0	0	00
11	75	06	04	00	00	0	0	0	0	0	00
12	76	06	04	00	00	0	0	0	0	0	00
13	77	06	04	00	00	0	0	0	0	0	00
14	62	04	06	00	00	0	0	0	0	0	00
15	54	04	06	00	00	0	0	0	0	0	00
16	06	04	06	00	00	0	0	0	0	0	00
17	33	07	06	00	00	0	0	0	0	0	00
20	36	07	06	00	00	0	0	0	0	0	00
21	35	07	06	00	00	0	0	0	0	0	00
22	37	07	06	00	00	0	0	0	0	0	00
23	23	04	06	25	00	0	0	0	0	0	00
24	70	00	06	00	00	0	0	0	0	0	00
25	26	04	06	27	00	0	0	0	0	0	00
26	70	00	06	00	00	0	0	0	0	0	00
27	17	06	04	31	00	0	0	0	0	0	00
30	70	00	06	00	00	0	0	0	0	0	00
31	70	00	04	00	00	0	0	0	1	0	00
32	74	10	06	00	00	0	0	0	0	0	00
33	74	10	06	37	00	0	0	0	0	0	00
34	74	10	01	00	00	0	0	0	0	0	00
35	74	10	01	00	00	0	0	0	0	0	00
36	74	01	01	00	00	0	0	0	1	0	00
37	70	00	10	00	00	0	0	0	0	0	00
40	72	04	05	00	00	4	0	0	0	0	00
41	72	04	06	00	00	0	0	0	0	0	00
42	62	06	04	00	00	0	0	0	0	0	00
43	72	04	06	00	00	0	0	0	0	0	00
44	70	00	04	00	00	0	0	1	0	0	00
45	72	06	04	00	00	0	0	0	0	0	00
46	70	00	10	00	00	0	0	0	0	0	00
47	70	00	04	00	00	1	0	0	0	0	00
50	71	04	05	00	00	0	0	0	0	0	00
51	33	04	06	00	00	0	0	0	0	0	00
52	13	06	06	00	00	0	0	0	0	0	00
53	70	00	04	00	00	6	0	0	0	0	00
54	71	06	04	00	00	0	0	0	0	0	00
55	71	06	04	60	00	1	0	0	0	0	00
56	70	00	10	00	00	0	1	0	0	0	00
57	71	06	05	55	00	7	0	0	0	0	00
60	70	00	04	00	00	0	0	0	0	0	00
61	70	00	04	00	00	0	0	0	0	0	00
62	70	00	10	00	00	0	0	0	0	0	00
63	77	04	05	00	00	1	0	1	1	0	00
64	71	04	06	00	00	0	0	0	0	0	00
65	72	04	06	00	00	0	0	0	0	0	00
66	54	04	06	00	00	0	0	0	0	0	00
67	70	00	06	00	00	0	0	0	0	0	00

Simulation parameters:

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004000
 START-ADDR. REGISTER = 01
 REGISTER FOR LOOP-COUNTER 1 = 0005
 REGISTER FOR LOOP-COUNTER 2 = 0004
 REGISTER FOR LOOP-COUNTER 3 = 0001

Printout from simulation:

SIMULATION OF PROGRAM EXECUTION

NO TRIGGER-CONDITION GIVEN

TIME	PROGRAM LOCATION	RS0	RS1	RS2	RS3	LC1	LCR1A	LC2	LC3	NEXT PC
000000	01	00	00	00	00	0000	0000	0000	0000	02
000001	02	00	00	00	00	0005	0000	0004	0001	03
000002	03	00	00	00	00	0005	0000	0004	0000	04
000003	04	00	00	00	00	0005	0000	0004	0001	05
000004	05	00	00	00	00	0005	0000	0004	0001	06
000005	06	00	00	00	00	0005	0000	0004	0001	07
000006	07	00	00	00	00	0005	0000	0004	0001	10
000007	10	00	00	00	00	0005	0000	0004	0001	11
000010	11	00	00	00	00	0005	0000	0004	0001	12
000011	12	00	00	00	00	0005	0000	0004	0001	13
000012	13	00	00	00	00	0005	0000	0004	0001	14
000013	14	00	00	00	00	0005	0000	0004	0001	15
000014	15	00	00	00	00	0005	0000	0004	0001	16
000015	16	00	00	00	00	0005	0000	0004	0001	17
000016	17	00	00	00	00	0005	0000	0004	0001	20
000017	20	00	00	00	00	0005	0000	0004	0001	21
000020	21	00	00	00	00	0005	0000	0004	0001	22
000021	22	00	00	00	00	0005	0000	0004	0001	23
000022	23	00	00	00	00	0005	0000	0004	0001	25
000023	25	00	00	00	00	0005	0000	0004	0001	27
000024	27	00	00	00	00	0005	0000	0004	0001	31
000025	31	00	00	00	00	0005	0000	0004	0001	32
000026	32	00	00	00	00	0005	0000	0004	0000	33
000027	33	33	00	00	00	0005	0000	0004	0000	34
000030	34	34	33	00	00	0005	0000	0004	0000	35
000031	35	35	34	33	00	0005	0000	0004	0000	36
000032	36	36	35	34	33	0005	0000	0004	0000	36
000033	36	35	34	33	36	0005	0000	0004	7777	35
000034	35	34	33	36	35	0005	0000	0004	7776	34
000035	34	33	36	35	34	0005	0000	0004	7776	33
000036	33	36	35	34	33	0005	0000	0004	7776	31
WARNING : IN PROGR. LOC. 37 REGISTER-STACK VALUE LOST										
000037	37	36	35	34	33	0005	0000	0004	7776	40
000040	40	40	36	35	34	0005	0000	0004	7776	40

LOOP-COUNTER 1 IS DECREMENTED

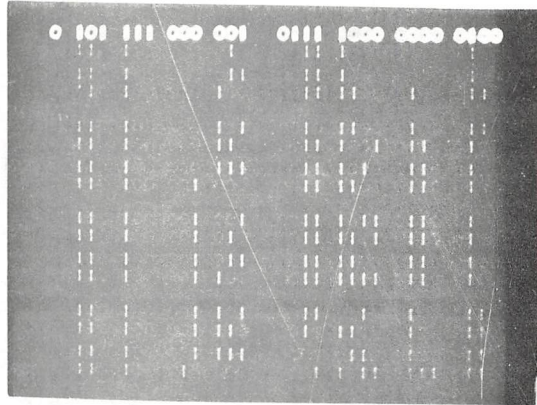
Printout for testprogram H1 cont:

LOOP-COUNTER 2 IS DECREMENTED										
000070	40	40	36	35	34	0005	0000	0000	7776	41
000071	41	40	36	35	34	0004	0000	0000	7776	42
000072	42	40	36	35	34	0004	0000	0000	7776	43
000073	43	40	36	35	34	0004	0000	0000	7776	44
000074	44	40	36	35	34	0004	0000	0000	7776	45
000075	45	40	36	35	34	0004	0000	7777	7776	46
WARNING : IN PROGR. LOC. 46 REGISTER-STACK VALUE LOST										
000076	46	40	36	35	34	0004	0000	7777	7776	47
000077	47	47	40	36	35	0004	0000	7777	7776	50
000100	50	47	40	36	35	0003	0000	7777	7776	47
000101	47	47	40	36	35	0003	0000	7777	7776	50
000102	50	47	40	36	35	0002	0000	7777	7776	47
000103	47	47	40	36	35	0002	0000	7777	7776	50
000104	50	47	40	36	35	0001	0000	7777	7776	47
000105	47	47	40	36	35	0001	0000	7777	7776	50
000106	50	47	40	36	35	0000	0000	7777	7776	51
000107	51	47	40	36	35	0000	0000	7777	7776	52
000110	52	47	40	36	35	0000	0000	7777	7776	53
000111	53	47	40	36	35	0000	0000	7777	7776	54
000112	54	47	40	36	35	0003	0000	7777	7776	55
000113	55	47	40	36	35	0003	0000	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000114	56	47	40	36	35	0004	0004	7777	7776	57
000115	57	57	47	40	36	0004	0004	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000121	57	57	47	40	36	0000	0004	7777	7776	55
000122	55	57	47	40	36	0004	0004	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000123	56	57	47	40	36	0003	0003	7777	7776	57
000124	57	57	57	47	40	0003	0003	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000127	57	57	57	47	40	0000	0003	7777	7776	55
000130	55	57	57	47	40	0003	0003	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000131	56	57	57	47	40	0002	0002	7777	7776	57
000132	57	57	57	57	47	0002	0002	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000134	57	57	57	57	47	0000	0002	7777	7776	55
000135	55	57	57	57	47	0002	0002	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000136	56	57	57	57	47	0001	0001	7777	7776	57
000137	57	57	57	57	57	0001	0001	7777	7776	57
000140	57	57	57	57	57	0000	0001	7777	7776	55
000141	55	57	57	57	57	0001	0001	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000142	56	57	57	57	57	0000	0000	7777	7776	57
000143	57	57	57	57	57	0000	0000	7777	7776	55
000144	55	57	57	57	57	0000	0000	7777	7776	60
000145	60	57	57	57	57	7777	0000	7777	7776	61
000146	61	57	57	57	57	7777	0000	7777	7776	62
WARNING : IN PROGR. LOC. 62 REGISTER-STACK VALUE LOST										
000147	62	57	57	57	57	7777	0000	7777	7776	63
000150	63	63	57	57	57	7777	0000	7777	7776	63
LOOP-COUNTER 1 IS DECREMENTED										
LOOP-COUNTER 2 IS DECREMENTED										
LOOP-COUNTER 3 IS DECREMENTED										
010146	63	63	57	57	57	0001	0000	0001	0000	64
010147	64	63	57	57	57	0000	0000	0000	7777	65
010150	65	63	57	57	57	0000	0000	0000	7777	66
010151	66	63	57	57	57	0000	0000	0000	7777	67
010152	67	63	57	57	57	0000	0000	0000	7777	68

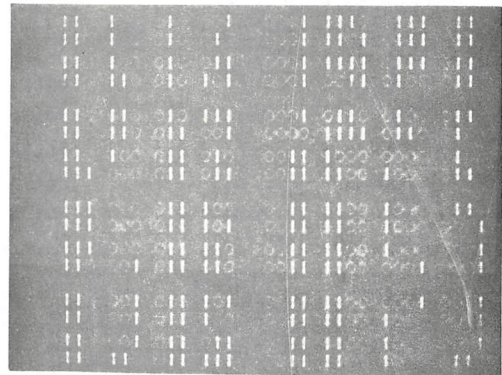
NO PROGRAM ERRORS WERE DETECTED
CPU-TIME IN CORRELATOR IS 701.67 USEC

Test on correlator system: Trigger point PC=0 in channel A,
bits 5-0 (LS

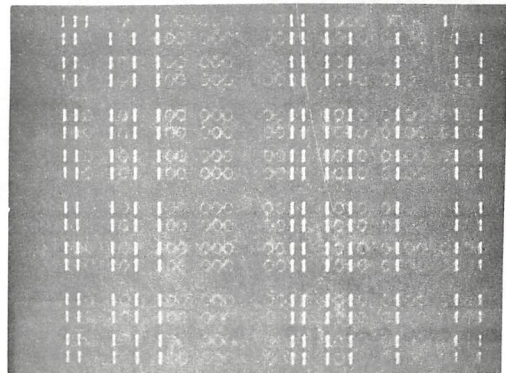
clock int. 0



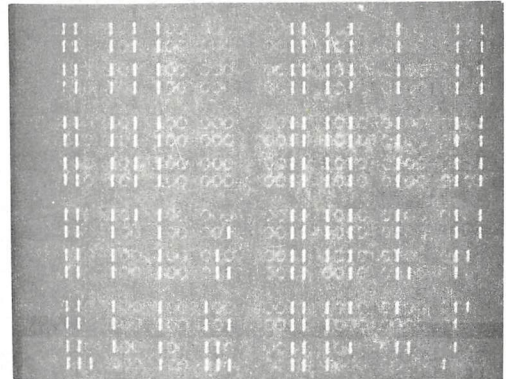
clock int. 20_B



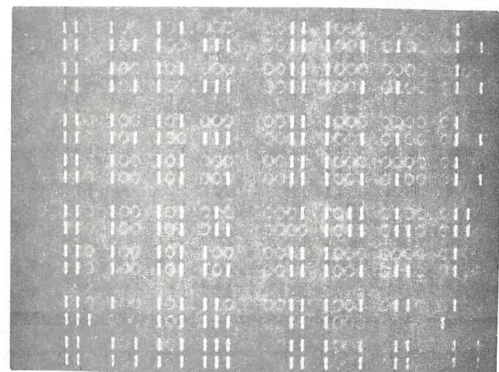
clock int. 40₈



clock int. 60₈

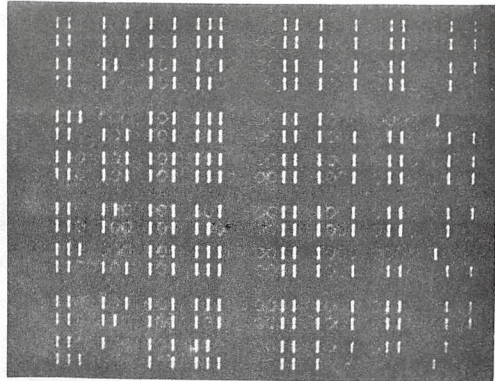


clock int. 100₈

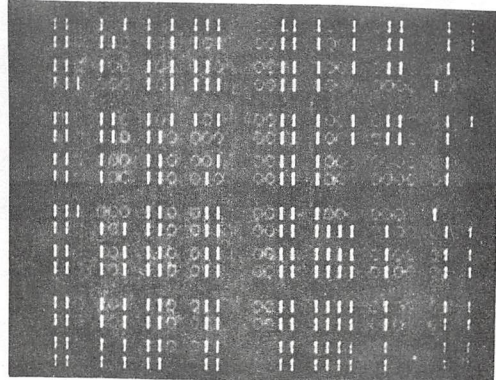


Display-output for testprogram H1 Cont.

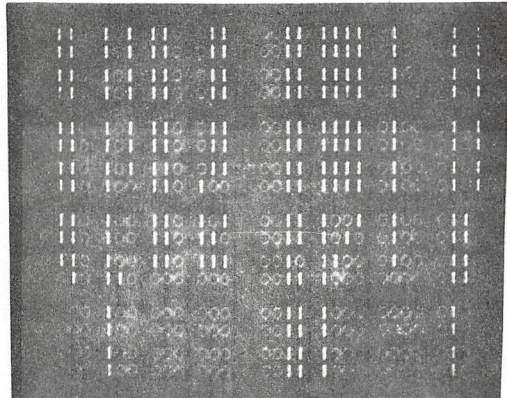
clock int. 120₈



clock int. 140₈



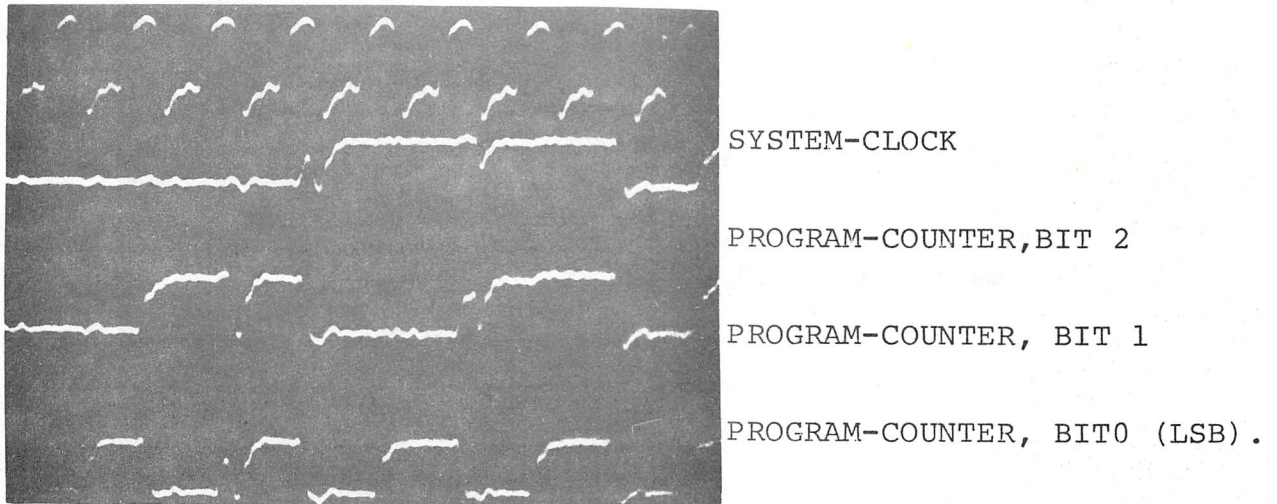
clock int. 10140₈

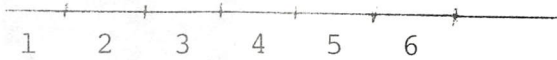


3.2.3 TIMING-DIAGRAM FOR PROGRAM COUNTER

Testing is performed with the 4-channel oscilloscope triggered from the logic-state analyzer (trigger is a predefined value of the program-counter).

START-SEQUENCE FOR TEST-PROGRAM H1:



PROGRAM-COUNTER: 
x:167 n/sec/div, y:0,5 v/div

Measured signal delay from system-clock:

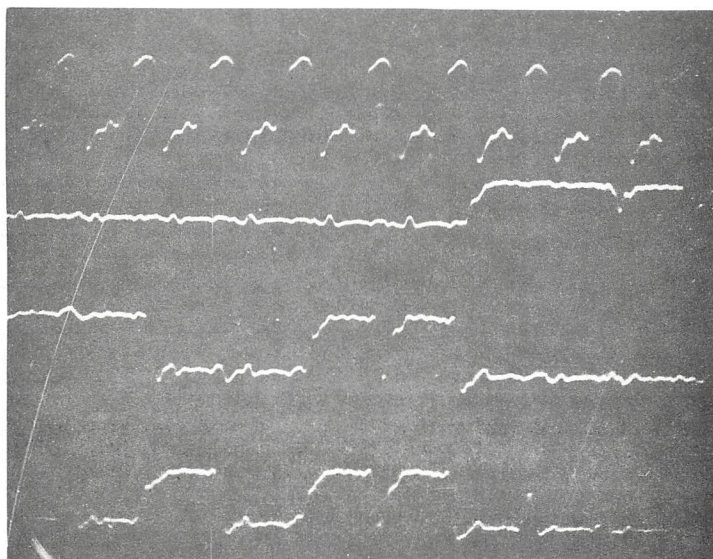
Program counter bits: 50 nsec_{TYP}

Measurement of maximum carry-propagation in micro-program sequences
Trigger-value on analyzer: PC=31.

Maximum setup-time of PC-value 40 from previous value 37:

70 nsec. (MSB bit PC).

Display for test-program H1:



SYSTEM CLOCK

PC, bit 5 (MSB)

PC, bit 1

PC, bit 0 (LSB)

Program-counter: 36 35 34 33 37 40 40 40

x:167 nsec/div, y=0,5 v/div

3.3. TESTS ON THE ADDRESS PROCESSORS APB AND APM

Logic analyzer connections used:

Channel B	Card terminal	Signal name
bit 0	CM5,2B1	Address bus APM, bit 0 (LSB)
1	CM5,2B2	_____ _____ 1
2	CM5,2B3	_____ _____ 2
3	CM5,2B4	_____ _____ 3
4	CM5,2B5	_____ _____ 4
5	CM5,2B6	_____ _____ 5
6	CM5,2B7	_____ _____ 6
7	CM5,2B8	_____ _____ 7
8	CM5,2B9	_____ _____ 8
9	CM5,2B10	_____ _____ 9
10	CM5,2B11	_____ _____ 10
11	CM5,2B12	_____ _____ 11 (MSB)
12	NOOP	
13	NOOP	
14	NOOP	
15	NOOP	
clock input (↑)	CM5,1A32	SYSTEM CLOCK

Channel A	Card terminal	Signal name
bit 0	CM3,1A18	Address bus APB1, bit 0 (LSB)
1	CM3,1A17	_____ _____ 1
2	CM3,1A16	_____ _____ 2
3	CM3,1A15	_____ _____ 3
4	CM3,1A14	_____ _____ 4
5	CM3,1A13	_____ _____ 5
6	CM3,1A12	_____ _____ 6
7	CM3,1A11	_____ _____ 7
8	CM3,1A10	_____ _____ 8
9	CM3,1A9	_____ _____ 9
10	Cn3,1A8	_____ _____ 10
11	Cn3,1A7	_____ _____ 11
12	CM3,1A6	_____ _____ 12
13	CM3,1A5	_____ _____ 13
14	CM3,1A4	_____ _____ 14
15	CM3,1A3	_____ _____ 15 (MSB)
clock input (↑)	CM4,1A32	SYSTEM CLOCK
qualifier Q0	CM1,1A3	START COMPUTE (USED AS A TRIGGER)

Two fixed-file programs have been constructed for testing the different arithmetical and reloading functions of the address-processors APB and APM in parallel.

PROGRAM NAMES.

TESTPROGRAM H2: TESTS ON ARITMETICAL FUNCTIONS ON ADDRESS PROCESSOR.

TESTPROGRAM H3: TESTS ON REGISTER-STACK LOADING AND ACCUMULATIONS IN APB, APM.

TESTING WITH H2:

The main purpose of H2 is testing that the register-stack is loaded with correct values before start and then the different ADD/SUB functions are tested.

The testing of the register-stack is performed with the following data-values in the data-field:

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004000
START-ADDR. REGISTER = 01

AFB-STACK :	APM-STACK :
REG.00=000000	REG.00=0000
REG.01=177777	REG.01=7777
REG.02=000001	REG.02=0001
REG.03=000002	REG.03=0002
REG.04=000004	REG.04=0004
REG.05=052525	REG.05=2525
REG.06=000010	REG.06=0010
REG.07=000020	REG.07=0020
REG.10=000040	REG.10=0040
REG.11=000100	REG.11=0100
REG.12=125252	REG.12=5252
REG.13=000200	REG.13=0200
REG.14=000400	REG.14=0400
REG.15=001000	REG.15=1000
REG.16=002000	REG.16=2000
REG.17=004000	REG.17=4000

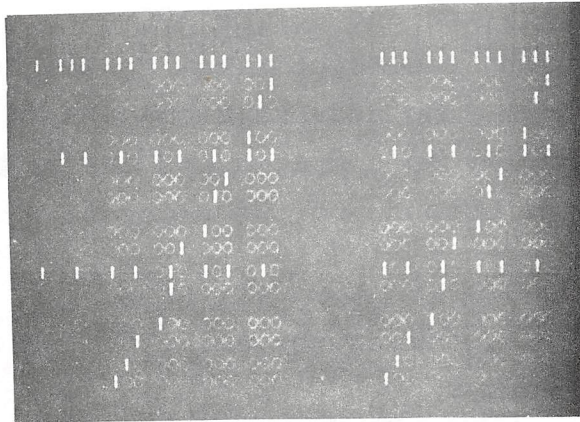
After start the program scans location 1 to 71, and the functions tested are given on the following page. The micro-instructions for the APM are the same, and with the test-connections given above, the hardware testing can be done in parallel on the two processors.

H2 listing:

AFB-INSTRUCTIONS DEFINED							
MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT	
00	7	4	1	00	00	0	
01	4	0	1	00	00	0	
02	4	0	1	01	00	0	
03	4	0	1	02	00	0	
04	4	0	1	03	00	0	
05	4	0	1	04	00	0	
06	4	0	1	05	00	0	
07	4	0	1	06	00	0	
10	4	0	1	07	00	0	
11	4	0	1	10	00	0	
12	4	0	1	11	00	0	
13	4	0	1	12	00	0	
14	4	0	1	13	00	0	
15	4	0	1	14	00	0	
16	4	0	1	15	00	0	
17	4	0	1	16	00	0	
20	4	0	1	17	00	0	
21	3	0	1	00	00	0	
22	3	0	1	00	01	0	
23	3	0	1	00	02	0	
24	3	0	1	00	03	0	
25	3	0	1	00	04	0	
26	3	0	1	00	05	0	
27	3	0	1	00	06	0	
30	3	0	1	00	07	0	
31	3	0	1	00	10	0	
32	3	0	1	00	11	0	
33	3	0	1	00	12	0	
34	3	0	1	00	13	0	
35	3	0	1	00	14	0	
36	3	0	1	00	15	0	
37	3	0	1	00	16	0	
40	3	0	1	00	17	0	
41	1	0	1	05	12	0	
42	1	1	1	05	12	0	
43	1	2	1	05	12	0	
44	1	3	1	05	12	0	
45	1	4	1	05	12	0	
46	1	5	1	05	12	0	
47	1	6	1	05	12	0	
50	1	7	1	05	12	0	
51	4	0	0	01	00	0	
52	0	0	1	02	00	0	
53	0	1	1	02	00	0	
54	0	2	1	02	00	0	
55	0	3	1	02	00	0	
56	0	4	1	02	00	0	
57	0	5	1	02	00	0	
60	0	6	1	02	00	0	
61	0	7	1	02	00	0	
62	2	0	1	00	00	0	
63	2	1	1	00	00	0	
64	2	2	1	00	00	0	
65	2	3	1	00	00	0	
66	2	4	1	00	00	0	
67	2	5	1	00	00	0	
70	2	6	1	00	00	0	
71	2	7	1	00	00	0	

Display output:

stm 1.

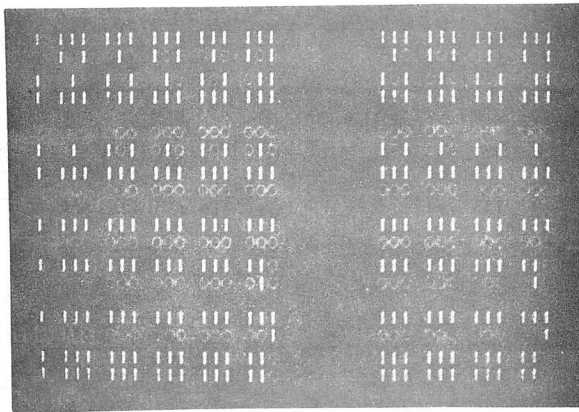


Delay: A-channel: 4
B-channel:5

Same values should be shown also for delay:

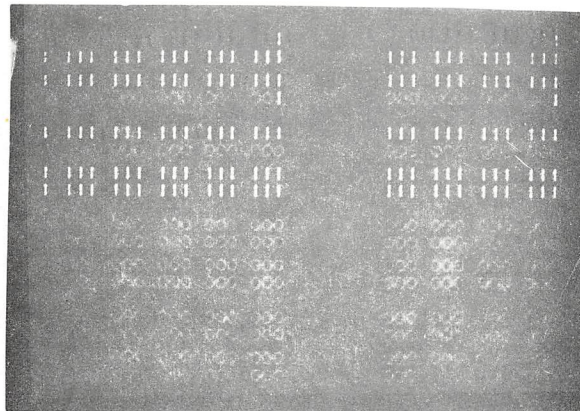
A-channel:20
B-channel:21

stm 41.



Delay: A-channel:36
B-channel:37

stm 61.



Delay: A-channel:52
B-channel:53

Stability-test using program H2:

Disconnect bits 12-15 on A-channel and set analyzer in "HALT IF \neq B \rightarrow IF A \neq B" operation and set delays as given in the previous test. By using the repetitive "CORRELATOR START"-function of CORRSIM program, the address from APB and APM (only 12 bits) can constantly be compared and the analyzer is detecting if bit-errors at output of the processors are occurring.

The module was started 37777_8 times for all given delays and no bit-errors were detected.

TESTING WITH H3:

The program has three subroutines for checking processor-accumulation, register-stack internal reloading and special functions of the APB-processor.

Subroutine 1 has startaddress at location 1 and has the program-field 1- 12_8 . The testing uses the same test-connections as for H1 with the following corrections:

Channel b	Card-terminal	Signal name
bit 12	CM5, 1A22	Program-counter, bit 0 (LSB)
13	CM5, 1A21	- " - bit 1
14	CM5, 1A20	- " - 2
15	CM5, 1A19	- " - 3

Channel A: Disable the qualifier Qo trigger.

In subroutine 1 the register accumulation mode is tested.
 The program operates on both address-processors in parallel.
 The following function is done:

REGISTER 0 → REGISTER 17 (loading of start value)
 REGISTER 17 + REGISTER 1 → REGISTER 17 (accumulation
 with incrementvalue in reg. 1).

The program is looping on the last operation, and the number
 of loops is determined by the product of values in loop-counter
 1, 2 and 3. At micro-instruction no. 12 the accumulation result
 is given. The subroutine instructions for program-control
 and APB-operation (same for APM) are the following:

PROGRAM-INSTRUCTIONS DEFINED											
MEM-LOC.	COND.	CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
00		70	00	04	00	0	0	0	0	0	00
01		70	00	10	00	0	0	0	2	0	00
02		70	00	04	00	0	0	0	1	0	00
03		70	00	10	00	0	0	3	0	0	00
04		70	00	04	00	0	0	1	0	0	00
05		70	00	04	00	2	0	0	0	0	00
06		70	00	10	00	1	0	0	0	0	00
07		71	00	05	00	1	0	0	0	0	00
10		72	00	05	00	0	0	0	0	0	00
11		74	00	05	00	0	0	0	0	0	00
12		70	00	06	00	0	0	0	0	0	00

APB-INSTRUCTIONS DEFINED							
MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT	
00	7	4	1	00	00	0	
01	4	0	3	00	17	0	
02	7	4	1	00	00	0	
03	7	4	1	00	00	0	
04	7	4	1	00	00	0	
05	7	4	1	00	00	0	
06	7	4	1	00	00	0	
07	1	0	3	01	17	0	
10	7	4	1	00	00	0	
11	7	4	1	00	00	0	
12	3	0	1	00	00	0	

Test-results with subroutine 1:

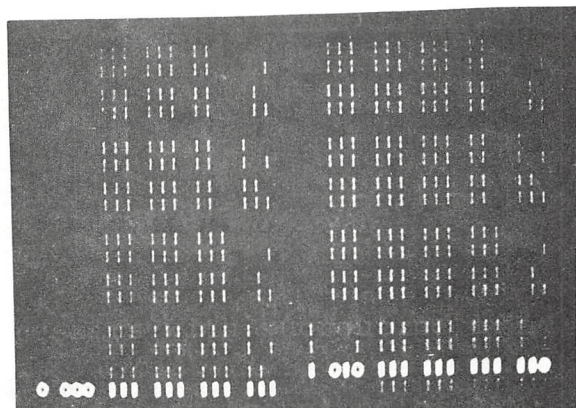
I. Testing max. counting of APM:

Parameter setup:

REGISTERS IN DATAFIELD DEFINED

```
STATUS-REGISTER      = 004000
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 7777
REGISTER FOR LOOP-COUNTER 2 = 0001
REGISTER FOR LOOP-COUNTER 3 = 0001
  APB-STACK :
  REG.00=000000
  REG.01=000001
  APM-STACK :
  REG.00=0000
  REG.01=0001
```

Display: end-triggered on PC=12, ch A: no delay, ch B:
1 delay (display APB, APM equal).

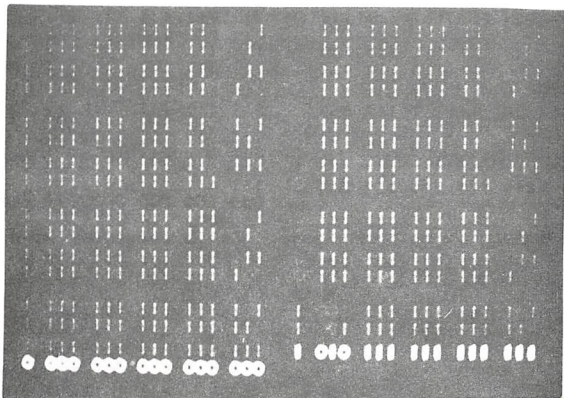


Display: end-triggered on PC=12, ch A: no delay, ch B: 1 delay
(display APB, APM equal).

REGISTERS IN DATAFIELD DEFINED

```
STATUS-REGISTER      = 004000
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 1000
REGISTER FOR LOOP-COUNTER 2 = 0200
REGISTER FOR LOOP-COUNTER 3 = 0001
  APB-STACK :
  REG.00=000000
  REG.01=000001
  APM-STACK :
  REG.00=0000
  REG.01=0001
```

Display (same trigger-conditions as before):



Subroutine 2 is designed for checking the processor register-stack loading in parallel for APB and APM. Subroutine 2 has startaddress at 13 and uses the memory-locations 13-52₈. The program-counter is moving continuous from 13 to 62 and back to zero. During this execution the loading of the register-stacks are address-reverses, that is:

reg. 0 → reg 17₈ and reg 17₈ → reg 0
reg. 1 → reg 16 and reg 16 → reg 1
.
.
.
.
.
.

After After 2. start the register loading should be the same as at the start.

Subroutine listing for APB (same instructions are used for APM):

APB-INSTRUCTIONS DEFINED						
MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT
13	3	0	0	00	00	0
14	4	0	3	17	00	0
15	2	0	3	00	17	0
16	3	0	0	00	01	0
17	4	0	3	16	01	0
20	2	0	3	00	16	0
21	3	0	0	00	02	0
22	4	0	3	15	02	0
23	2	0	3	00	15	0
24	3	0	0	00	03	0
25	4	0	3	14	03	0
26	2	0	3	00	14	0
27	3	0	0	00	04	0
30	4	0	3	13	04	0
31	2	0	3	00	13	0
32	3	0	0	00	05	0
33	4	0	3	12	05	0
34	2	0	3	00	12	0
35	3	0	0	00	06	0
36	4	0	3	11	06	0
37	2	0	3	00	11	0
40	3	0	0	00	07	0
41	4	0	3	10	07	0
42	2	0	3	00	10	0
43	4	0	1	00	00	0
44	4	0	1	01	00	0
45	4	0	1	02	00	0
46	4	0	1	03	00	0
47	4	0	1	04	00	0
50	4	0	1	05	00	0
51	4	0	1	06	00	0
52	4	0	1	07	00	0
53	4	0	1	10	00	0
54	4	0	1	11	00	0
55	4	0	1	12	00	0
56	4	0	1	13	00	0
57	4	0	1	14	00	0
60	4	0	1	15	00	0
61	4	0	1	16	00	0
62	4	0	1	17	00	0

Test-results using subroutine 2:

Same test-connections as for subroutine 1. The display triggered on program-counter eq. to 3 (only 4 LSB bits used) and delay=19 in channel A, delay=20 in channel B.

Test-values loaded into data-field:

REGISTERS IN DATAFIELD DEFINED

```
STATUS-REGISTER      = 004000
START-ADDR, REGISTER = 13
REGISTER FOR LOOP-COUNTER 1 = 1000
REGISTER FOR LOOP-COUNTER 2 = 0200
REGISTER FOR LOOP-COUNTER 3 = 0001
```

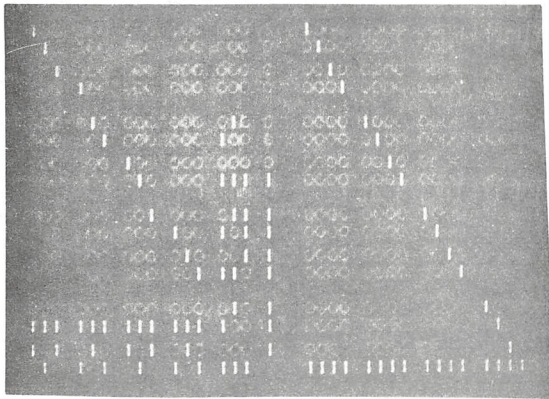
APB-STACK :

```
REG.00=000001
REG.01=000002
REG.02=000004
REG.03=000010
REG.04=000020
REG.05=000040
REG.06=000100
REG.07=000200
REG.10=000400
REG.11=001000
REG.12=002000
REG.13=004000
REG.14=010000
REG.15=020000
REG.16=040000
REG.17=177777

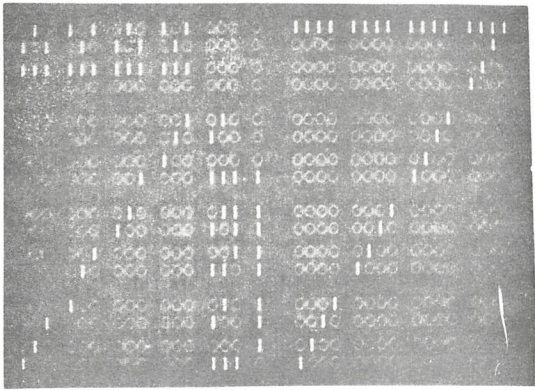
APM-STACK :
```

```
REG.00=000001
REG.01=000002
REG.02=000004
REG.03=000010
REG.04=000020
REG.05=000040
REG.06=000100
REG.07=000200
REG.10=000400
REG.11=001000
REG.12=002000
REG.13=004000
REG.14=010000
REG.15=020000
REG.16=040000
REG.17=52525
```

Display after 1. start:



Display after 2. start:



Subroutine 3, with start at 63 (uses 63-70₈), is a test-program only for the APB. At locations 65 the loop-counter 1 is reloaded from APB, reg. 17 with the function LCR1=RSAPB (17)=20₈. At location 70₈, the register stack registers are displayed by the special function "SELECT", which connects B-address input on APB to loop-counter 1, and this counter is decremented in location 70.

Subroutine listing:

PROGRAM-INSTRUCTIONS DEFINED											
MEM-LOC.	COND.	CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
63	70	00	04	00	00	0	0	0	0	0	00
64	70	00	04	00	00	0	0	0	0	0	00
65	70	00	04	00	00	0	0	0	0	1	22
66	70	00	04	00	00	0	0	0	0	0	00
67	70	00	10	00	00	2	0	0	0	0	00
70	71	06	05	00	00	1	0	0	0	0	00

APB-INSTRUCTIONS DEFINED						
MEM-LOC.	ALU-SOURCE	ALU-FUNCTION	ALU-DESTIN.	A-ADDR.	B-ADDR.	SELECT
63	7	4	1	00	00	0
64	7	4	1	00	00	0
65	4	0	1	17	00	0
66	7	4	1	00	00	0
67	7	4	1	00	00	0
70	3	0	1	00	00	1

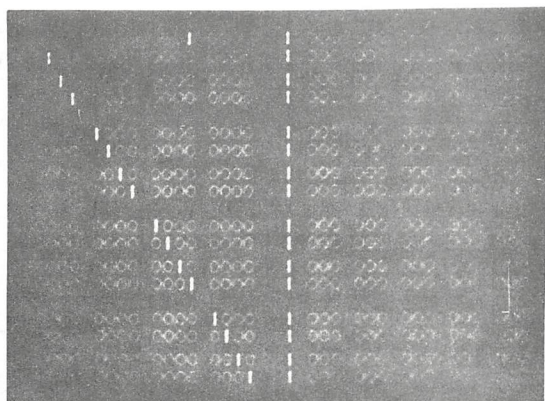
Datafield setup:

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004000
 START-ADDR. REGISTER = 63
 REGISTER FOR LOOP-COUNTER 1 = 1000
 REGISTER FOR LOOP-COUNTER 2 = 0200
 REGISTER FOR LOOP-COUNTER 3 = 0001

APB-STACK :	AFM-STACK :
REG.00=000001	REG.00=0001
REG.01=000002	REG.01=0002
REG.02=000004	REG.02=0004
REG.03=000010	REG.03=0010
REG.04=000020	REG.04=0020
REG.05=000040	REG.05=0040
REG.06=000100	REG.06=0100
REG.07=000200	REG.07=0200
REG.10=000400	REG.10=0400
REG.11=001000	REG.11=1000
REG.12=002000	REG.12=2000
REG.13=004000	REG.13=4000
REG.14=010000	REG.14=0000
REG.15=020000	REG.15=7777
REG.16=040000	REG.16=2525
REG.17=000020	REG.17=5252

Test-result: same connections as before, trigger on PC=3
(4LSB bits). Delay ch A: 9, delay ch. B: 6



3.4 TESTS ON MULTIPLIERS AND PARTIAL ACCUMULATORS

Testprogram H4 is designed for testing the 4 hardware multipliers and the subsequent add/subtract-function. The test is performed by probing on the correlator data-channels in parallel, and the test-function "HALT IF $A \neq B$ " on the logic state analyzer is used for detecting possible hardware errors. This is done while generating the same data-input to the channels (from test-memory) and making the same channel micro-operations. If data-output from the channels are the same, no errors have occurred.

Test-connections used:

Channle B	Card terminal	Signal name
bit 0	LC2,2A17	Data-channel 2, bit 0 (LSB)
1	LC2,2A16	----- " ----- 1
2	LC2,2A15	----- " ----- 2
3	LC2,2A14	----- " ----- 3
4	LC2,2A13	----- " ----- 4
5	LC2,2A12	----- " ----- 5
6	LC2,2A11	----- " ----- 6
7	LC2,2A10	----- " ----- 7
8	LC2,2A9	----- " ----- 8
9	LC2,2A8	----- " ----- 9
10	LC2,2A7	----- " ----- 10
11	LC2,2A6	----- " ----- 11
12	LC2,2A5	----- " ----- 12
13	LC2,2A4	----- " ----- 13
14	LC2,2A3	----- " ----- 14
15	LC2,2A2	----- " ----- 15 (MSB)

clock input (↑) CM5,1A32 System clock

Channel A	Card terminal	Signal name
bit 0	LC2,1A19	Data-channel 1, bit 0 (LSB)
1	LC2,1A18	----- " ----- 1
2	LC2,1A17	----- " ----- 2
3	LC2,1A16	----- " ----- 3
4	LC2,1A15	----- " ----- 4
5	LC2,1A14	----- " ----- 5
6	LC2,1A13	----- " ----- 6
7	LC2,1A12	----- " ----- 7
8	LC2,1A11	----- " ----- 8
9	LC2,1A10	----- " ----- 9
10	LC2,1A9	----- " ----- 10
11	LC2,1A8	----- " ----- 11
12	LC2,1A7	----- " ----- 12
13	LC2,1A6	----- " ----- 13
14	LC2,1A5	----- " ----- 14
15	LC2,1A4	----- " ----- 15 (MSB)

clock-input (↑) CM4,1A32 SYATEM CLOCK

qualifier Qo CM1,2A12 CORRELATOR BUSY

The display is triggered on active high qualifier Qo.

Display function:

- : Delay from 6-517 show testdata X (from loc.0-511), test loading B-reg.M1,M3
- : Delay from 519-1030, test loading Y data to registers B on M1,M3
- : Delay from 1032-1543, test loading X data to B-reg. on M2,M4
- : Delay from 1545-2056, test loading Y data to B-reg. on M2,M4
- : Delay from 2059-2570, test loading X data to A-reg. on M1,M3
- : Delay from 2573-3084, test loading Y data to A-reg. on M1,M3
- : Delay from 3087-3598, test loading X data to A-reg. on M2,M4
- : Delay from 3601-4112, test loading Y data to A-reg. on M2,M4
- : Delay from 4114-4625, test loading $x^2 - x^2 \Rightarrow 0$
- : Delay from 4627-7186, test-sequence:

```
test a: X*Y
test b: 0
test c: 2X*Y
test d: X*Y
test e: 2Y2
```

Data-field for test:

REGISTERS IN DATAFIELD DEFINED

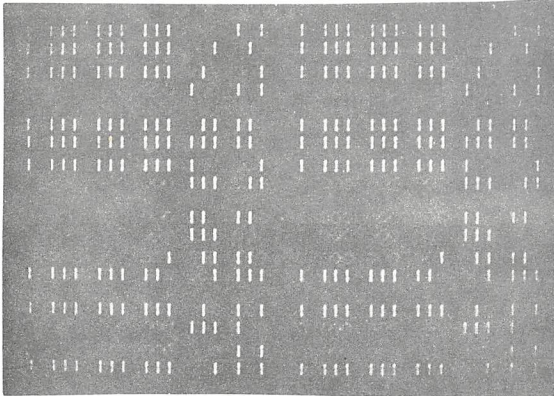
```
STATUS-REGISTER          = 004020
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 0777
  AFB-STACK :
  REG.00=000001
  REG.17=000154
```

AFM-STACK :

Display-output:

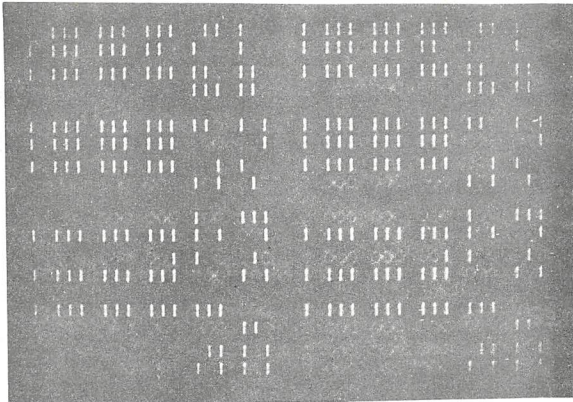
Delay = 6:

Simulation-result from CORRSIM:



177705
177712
177721
000045
177736
177776
177741
000073
000066
000070
000136
177617
177725
000074
000005
177715

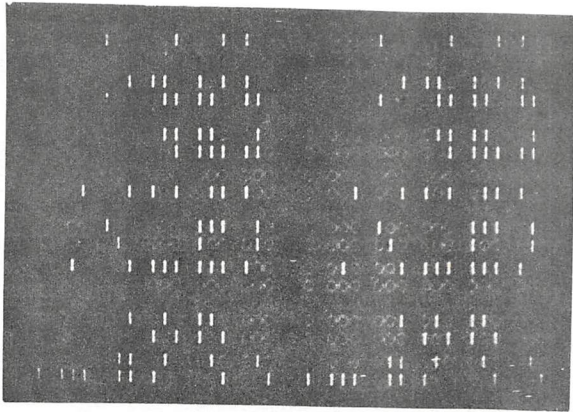
X-loading



177734
177644
177766
000076
177765
177701
177714
000052
000047
177751
000142
177705
177770
000006
000035
000055

Y-loading

Delay = 4627:



Mixed loading.

3.5 TESTS ON 32-BITS ACCUMULATORS

The accumulators are tested with the testprogram H5 which consists of 4 separate subroutines:

Subroutine 1: Isolated test on the accumulator function with generation of -1 from the data-channels without any computations on the data. This routine checks only the accumulator function.

Subroutine 2: Test of loading values directly from the test-data memory at input for testing the loading operation of the accumulators.

Subroutine 3: Test on the function

$$\sum_n x^2 + y^2$$

Subroutine 4: Test on the function

$$\sum_n x + y$$

The same processing is performed on both data-channels, except for subroutine 2 where x-value is generated on datapchannel 1, and y-value at the other.

Test-connections used:

The logic analyzer is connected to the data-channels on accumulator card LC2 (front-panel flat-cable connectors). It is recommended that the analyzer clock-bits are connected to the memory-write signal to the result-memory (terminals 2A12 on memory cards) and the digital scope is triggered on high-to-low transition of the clock-signal. The testing must be performed in two steps. (Note that when performing this test, the correlator memory card should be disconnected, due to noise injection on the power lines).

TESTPROGRAM 1: ACCUMULATION WITH - 1 2³² TIMES (SUBROUTINE 1)

Programlisting:

PROGRAM-INSTRUCTIONS DEFINED											
MEM-LOC.	COND.	CODE	CODE-B	CODE-A	ADDR.	LC1	LCR1A	LC2	LC3	RELOAD	R-ADDR.
00		40	00	04	00	0	0	0	0	0	00
01		70	00	10	00	0	0	0	2	0	00
02		70	00	10	00	0	0	3	1	0	00
03		70	00	04	00	2	0	1	0	0	00
04		70	00	10	00	1	0	0	0	0	00
05		71	00	05	00	1	0	0	0	0	00
06		72	00	05	00	0	0	0	0	0	00
07		74	06	05	00	0	0	0	0	0	00

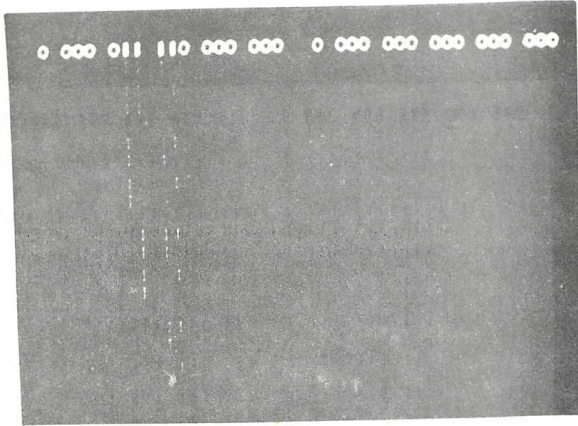
ACCUMULATOR INSTRUCTIONS DEFINED								
MEM-LOC.	STROBE	I/O	WRITE	READ	CLEAR1	SET1	CLEAR2	SET2
00	0		0	0	0	0	0	0
01	1		0	1	0	0	0	0
02	0		0	0	0	0	0	0
03	0		0	0	0	0	0	0
04	0		0	0	0	0	0	0
05	1		0	0	0	0	0	0
06	1		0	0	0	0	0	0
07	0		1	0	0	0	0	0

With the following data-field defined, the accumulator counts down from -1 (all ones) to 0.

REGISTERS IN DATAFIELD DEFINED

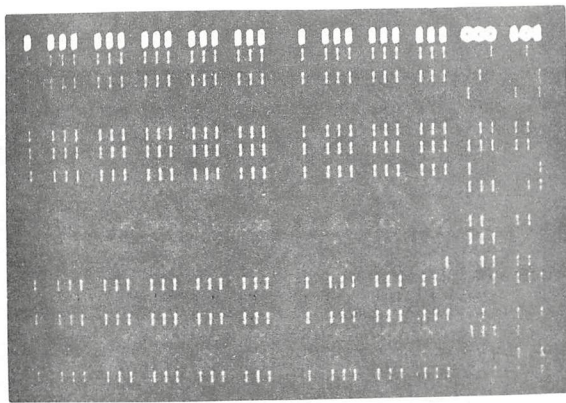
STATUS-REGISTER = 004020
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 7777
REGISTER FOR LOOP-COUNTER 2 = 4000
REGISTER FOR LOOP-COUNTER 3 = 1000

The last 16 values on the display are:



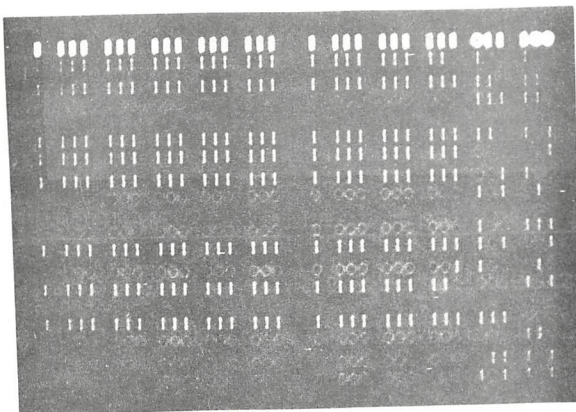
TESTPROGRAM 2. Direct transfer from test-memory to accumulators

The program is equal to the testprogram from file 4 of CORRISIM (start at 16). Data-channel 1: (first 16 x-values)



177777	177705
177777	177712
177777	177721
000000	000045
177777	177736
177777	177776
177777	177741
000000	000073
000000	000066
000000	000070
000000	000136
177777	177617
177777	177725
000000	000074
000000	000005
177777	177715

Data-channel 2: (first 16 y-values)



177777	177734
177777	177644
177777	177766
000000	000076
177777	177765
177777	177701
177777	177714
000000	000052
000000	000047
177777	177751
000000	000142
177777	177705
177777	177770
000000	000006
000000	000035
000000	000055

TESTPROGRAM 3: TESTS ON ACCUMULATION OF $\Sigma x^2 + y^2$

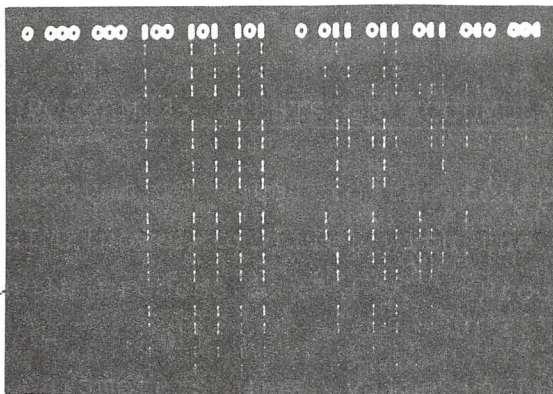
The program is equal to the testprogram from file 2 of CORRSIM (power-profile) with the exception that both data-channels process $\Sigma x^2 + y^2$. Program starts at loc. 21

Test parameters (max. value in LC1):

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004020
START-ADDR. REGISTER = 21
REGISTER FOR LOOP-COUNTER 1 = 7777
REGISTER FOR LOOP-COUNTER 2 = 0017
AFB-STACK :
REG.12=000177
REG.13=000001
REG.14=000000

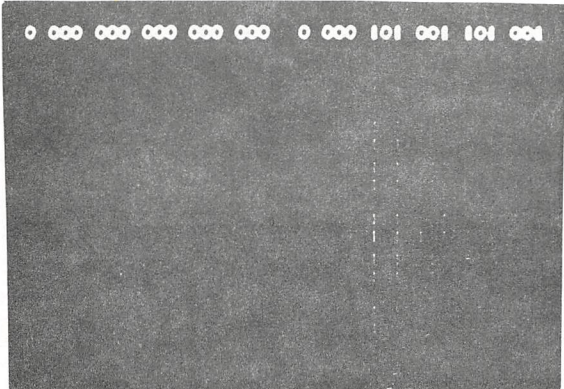
AFM-STACK :
REG.13=0001
REG.14=0000



000455	033321
000455	023041
000455	053132
000455	025765
000455	032372
000455	037352
000455	022115
000455	026011
000455	044451
000455	055614
000455	026754
000455	023601
000455	025201
000455	027660
000455	025622
000455	023235

TESTPROGRAM 4 (SUBROUTINE 4): TESTS ON ACCUMULATION OF $\Sigma x + y$:

The subroutine is equal to testprogram from file 2 of CORRIM, both data-channels are processing $\Sigma x + y$. Same test-parameters as for testprogram 3 with the exception that the program starts at 27.



000000	005151
000000	005325
000000	005516
000000	005211
000000	005400
000000	005452
000000	005317
000000	005223
000000	005137
000000	005552
000000	005372
000000	005247
000000	005223
000000	005214
000000	005272
000000	005273

3.6 RESULT-MEMORY TIMING

A small testprogram (H6) has been constructed for testing the basic memory-cycle. This includes the following functions:

- move content from memory to accumulators
- accumulate with data from the hardware multipliers
- move modified value back to memory

The program does the following for each instruction cycle:

Program-memory location	Function
0	Idle
1	Load value from loop-counter register 1 into loop-counter 1.
2	Load-value + 1 into result-memory locations 1777 ₈ .
3	Read value from memory location 0 (on first loop execution reset accumulator register), accumulate with -1 and load back to mem. loc.0.
4	Read value from mem. location 1777, accumulate with +1 and load back to loc. 1777.
5	Read value from mem. location 7777, accumulate with +1 and load back to loc. 7777. Decrement loop-counter 1. If loop-counter 1 equals 0 continue to staement 6, otherwise return to statement 3.
6	Go to statement 1.

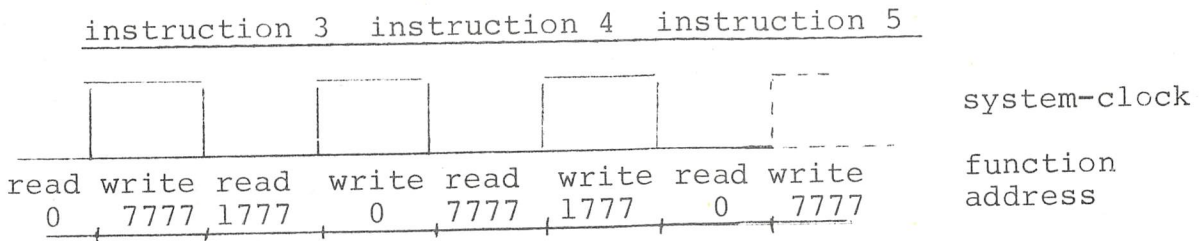
As given in microinstruction 6, the program has no end-statement and this makes it possible to analyze the waveterms with analog oscilloscope. A listing of the program can be found in Chapter 5.

The program uses the following defined parameters:

REGISTERS IN DATAFIELD DEFINED

```
STATUS-REGISTER      = 004020
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 0010
  APB-STACK ;
  REG.00=000160
  REG.01=000221
  REG.02=000154
  APM-STACK ;
  REG.00=0000
  REG.10=1777
  REG.11=7777
```

For the APB-stack the register 0 gives buffer-memory address for loading -1 to the accumulators. Registers 1 and 2 give address-reference to data value +1. Register 0 in the APM gives the result-memory location for testing accumulation with -1. Accumulation with /1 is tested on location given by REG. 10 - REG. 0. REGISTER 11 gives the address to the result-memory for the second +1 accumulation. With the given data-values the address generation to the result-memory is:



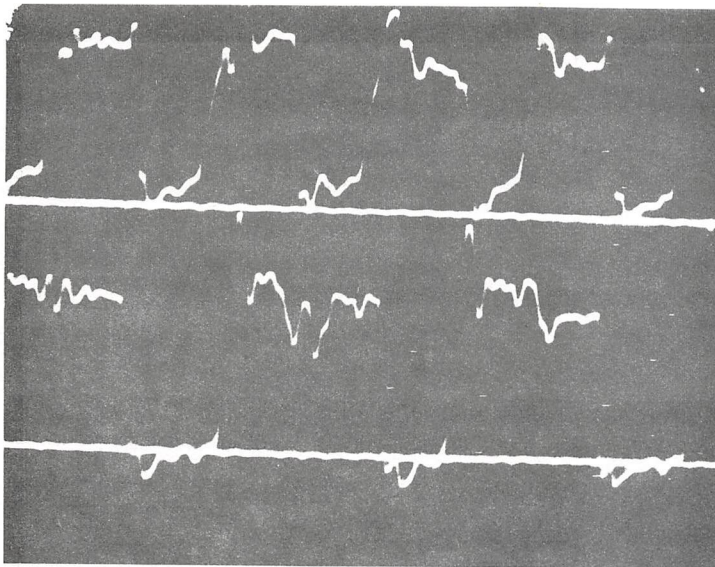
The program is constructed for making bit-inversion (address 0 address 1777) within a memory module, at the same time the data bits are inverted. (+1 to -1).

Test-results:

I. MEMORY-WRITE PULSE AND ADDRESS SETUP-TIMES

Testpoints: upper channel, write-pulse (active low) on data-channel 1 module.

Lower channel, LSB-bit for result-memory address, same memory module.



write-pulse

LSB-bit address

x: 100 nsec/div.

y: 2 v/div.

write write write
0 1777 7777

WRITE-PULSE WIDTH: 75 nsec (at 2 volts)

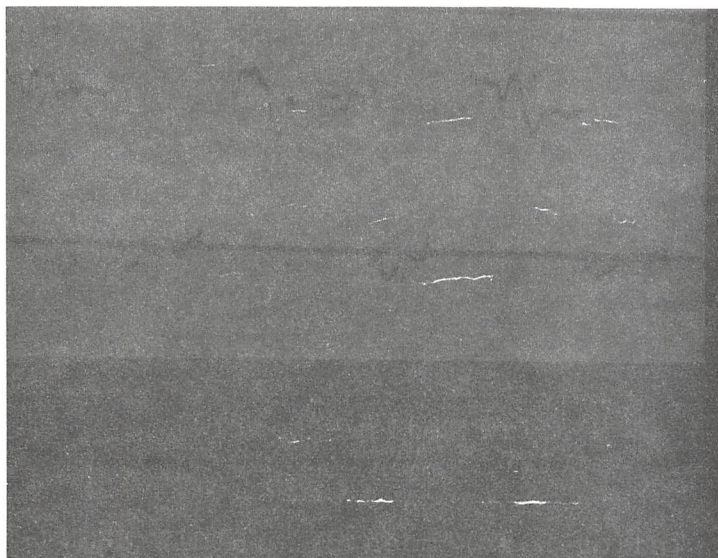
ADDRESS SETUP-TIME FOR WRITE: 10 nsec_{TYP}, 0 nsec_{MIN}

ADDRESS HOLD-TIME FROM WRITE: 20 nsec_{TYP}

II. DATA-RESPONSE ON READ/WRITE CYCLE:

1. channel: write-pulse
2. channel: LSB-bit memory address
3. channel: LSB-bit on data-out bus from memory.

Note that data-bus is in 3-state inhibit during memory write.



write-pulse

LSB-bit address

LSB-bit data out

x: 100 nsec/div.

y: 5 volts/div.

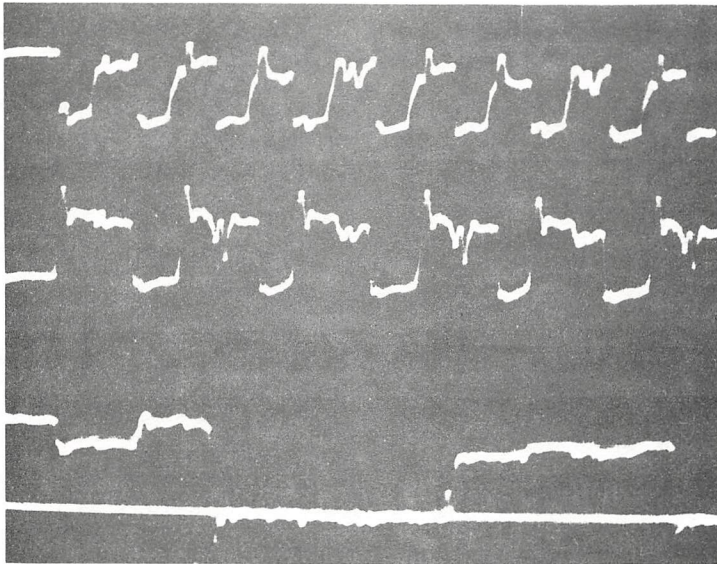
Read Read Read
0 1777 7777

WRITE RECOVERY TIME: 20 nsec_{TYP}

READ ACCESS TIME (ADDRESS TO DATA): 30 nsec_{TYP}

III. DATA SETUP-TIME FOR WRITE

1. channel: write-pulse
2. channel: LSB-bit address
3. channel: LSB-bit data input-bus to memory



write-pulse

LSB-bit address

LSB-bit data

x: 200 nsec/div.

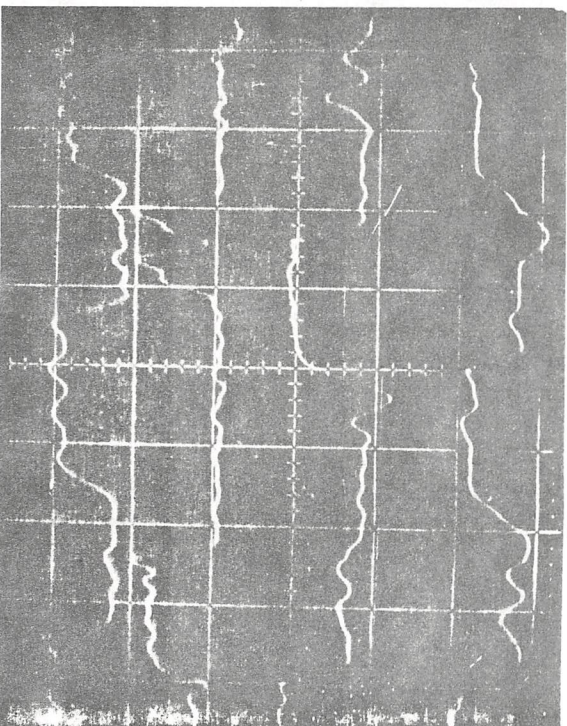
y: 5 volts/div.

DATA SETUP-TIME INACTIVE WRITE-PULSE: 90 nsec_{TYP}

DATA HOLD-TIME: 100 nsec_{TYP}

IV. DATA SETUP-TIME FOR TRANSFER TO ACCUMULATOR

1. channel: write-pulse
2. channel: LSB-bit address
3. channel: LSB-bit data output-bus to accumulator
4. channel: strobe-signal (high-to-low transition) on card-terminal (1B12) of accumulator.



write-pulse

LSB-bit address

LSB-bit data

Accumulator strobe-signal

x: 50 nsec/div.
y: 5 volts/div.

Read Read
0 1777

DATA SETUP-TIME: 15 nsec_C MIN

DATA HOLD-TIME: 25 nsec_{TYP}

4. SYSTEM TESTS

A set of CORRSIM files have been created for complete system tests. These tests include the complete correlator system with data transfer over the NORD-10 DMA-channel. For each test diagnostics on the correlator system can be made by visual inspection of data on display/listing or directly by table-comparison controlled by computer software. The data-table can be produced by the first DMA-transfer and all subsequent correlator-runs can be tested with this table. It is also possible to have automatic starts of the correlator with table-comparison for long-term stability tests of the correlator. For certain files it is also possible to produce the data-table from direct arithmetical simulation inside CORRSIM.

4.1 SYSTEM-TEST S1: TEST ON MICROPROGRAM EXECUTION

The program is stored on file (CORR)S1: data and test-preparation is only to load the program into the correlator before execution. Number of 16-bits words transferred on the DMA-channel is 161. The microprogram produces a mapping of the correlator program-counter and all typical program-instructions are tested. For detailed description of microprogram, see Appendix A. The program uses a fixed setupe of parameters in the data-field and this is stored on the file S1.

The test-program has been tested in the CORRSIM simulator for program execution, and a comparison table was created for test against data output from the correlator (testword 2 which contains the program-counter). Number of program-statements under test is 163_8 (equal to no. of executed clock-intervals). If the program-counter reaches location 76 after 16_8 clock-intervals, no program errors have been occurring.

Print from simulation of program S1. Comparison with correlator output is PROGRAM LOCATION in the second column.

SIMULATION OF PROGRAM EXECUTION

NO TRIGGER-CONDITION GIVEN

TIME	PROGRAM LOCATION	RS0	RS1	RS2	RS3	LC1	LCR1A	LC2	LC3	NEXT PC
000000	01	00	00	00	00	0000	0000	0000	0000	02
000001	02	00	00	00	00	0005	0000	0004	0001	03
000002	03	00	00	00	00	0005	0000	0004	0000	04
000003	04	00	00	00	00	0005	0000	0004	0001	05
000004	05	00	00	00	00	0005	0000	0004	0001	06
000005	06	00	00	00	00	0005	0000	0004	0001	07
000006	07	00	00	00	00	0005	0000	0004	0001	10
000007	10	00	00	00	00	0005	0000	0004	0001	11
000010	11	00	00	00	00	0005	0000	0004	0001	12
000011	12	00	00	00	00	0005	0000	0004	0001	13
000012	13	00	00	00	00	0005	0000	0004	0001	14
000013	14	00	00	00	00	0005	0000	0004	0001	15
000014	15	00	00	00	00	0005	0000	0004	0001	16
000015	16	00	00	00	00	0005	0000	0004	0001	17
000016	17	00	00	00	00	0005	0000	0004	0001	20
000017	20	00	00	00	00	0005	0000	0004	0001	21
000020	21	00	00	00	00	0005	0000	0004	0001	22
000021	22	00	00	00	00	0005	0000	0004	0001	23
000022	23	00	00	00	00	0005	0000	0004	0001	25
000023	25	00	00	00	00	0005	0000	0004	0001	27
000024	27	00	00	00	00	0005	0000	0004	0001	31
000025	31	00	00	00	00	0005	0000	0004	0001	32
000026	32	00	00	00	00	0005	0000	0004	0000	33
000027	33	33	00	00	00	0005	0000	0004	0000	34
000030	34	34	33	00	00	0005	0000	0004	0000	35
000031	35	35	34	33	00	0005	0000	0004	0000	36
000032	36	36	35	34	33	0005	0000	0004	0000	36
000033	36	35	34	33	36	0005	0000	0004	7777	35
000034	35	34	33	36	35	0005	0000	0004	7776	34
000035	34	33	36	35	34	0005	0000	0004	7776	33
000036	33	36	35	34	33	0005	0000	0004	7776	37
WARNING :	IN PROGR. LOC.	37	REGISTER-STACK	VALUE	LOST					
000037	37	36	35	34	33	0005	0000	0004	7776	40
000040	40	40	36	35	34	0005	0000	0004	7776	40

LOOP-COUNTER 1 IS DECREMENTED

Simulation of program S1, cont.

Address	PC	IR	DR	SR	SR	OP	OP	OP	OP	OP
LOOP-COUNTER 2 IS DECREMENTED										
000070	40	40	36	35	34	0005	0000	0000	7776	41
000071	41	40	36	35	34	0004	0000	0000	7776	42
000072	42	40	36	35	34	0004	0000	0000	7776	43
000073	43	40	36	35	34	0004	0000	0000	7776	44
000074	44	40	36	35	34	0004	0000	0000	7776	45
000075	45	40	36	35	34	0004	0000	7777	7776	46
WARNING : IN PROGR. LOC. 46 REGISTER-STACK VALUE LOST										
000076	46	40	36	35	34	0004	0000	7777	7776	47
000077	47	47	40	36	35	0004	0000	7777	7776	50
000100	50	47	40	36	35	0003	0000	7777	7776	47
000101	47	47	40	36	35	0003	0000	7777	7776	50
000102	50	47	40	36	35	0002	0000	7777	7776	47
000103	47	47	40	36	35	0002	0000	7777	7776	50
000104	50	47	40	36	35	0001	0000	7777	7776	47
000105	47	47	40	36	35	0001	0000	7777	7776	50
000106	50	47	40	36	35	0000	0000	7777	7776	51
000107	51	47	40	36	35	0000	0000	7777	7776	52
000110	52	47	40	36	35	0000	0000	7777	7776	53
000111	53	47	40	36	35	0000	0000	7777	7776	54
000112	54	47	40	36	35	0005	0000	7777	7776	55
000113	55	47	40	36	35	0005	0000	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000114	56	47	40	36	35	0004	0004	7777	7776	57
000115	57	57	47	40	36	0004	0004	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000121	57	57	47	40	36	0000	0004	7777	7776	55
000122	55	57	47	40	36	0004	0004	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000123	56	57	47	40	36	0003	0003	7777	7776	57
000124	57	57	57	47	40	0003	0003	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000127	57	57	57	47	40	0000	0003	7777	7776	55
000130	55	57	57	47	40	0003	0003	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000131	56	57	57	47	40	0002	0002	7777	7776	57
000132	57	57	57	57	47	0002	0002	7777	7776	57
LOOP-COUNTER 1 IS DECREMENTED										
000134	57	57	57	57	47	0000	0002	7777	7776	55
000135	55	57	57	57	47	0002	0002	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000136	56	57	57	57	47	0001	0001	7777	7776	57
000137	57	57	57	57	57	0001	0001	7777	7776	57
000140	57	57	57	57	57	0000	0001	7777	7776	55
000141	55	57	57	57	57	0001	0001	7777	7776	56
WARNING : IN PROGR. LOC. 56 REGISTER-STACK VALUE LOST										
000142	56	57	57	57	57	0000	0000	7777	7776	57
000143	57	57	57	57	57	0000	0000	7777	7776	55
000144	55	57	57	57	57	0000	0000	7777	7776	60
000145	60	57	57	57	57	7777	0000	7777	7776	61
000146	61	57	57	57	57	7777	0000	7777	7776	62
000147	62	57	57	57	57	7777	0000	7777	7776	63
000150	63	57	57	57	57	7777	0000	7777	7776	64
000151	64	57	57	57	57	7777	0000	7777	7776	65
000152	65	57	57	57	57	7777	0000	7777	7776	66
000153	66	57	57	57	57	7777	0000	7777	7776	67
000154	67	57	57	57	57	7777	0000	7777	7776	70
000155	70	57	57	57	57	7777	0000	7777	7776	71
000156	71	57	57	57	57	7777	0000	7777	7776	72
000157	72	57	57	57	57	7777	0000	7777	7776	73
000160	73	57	57	57	57	7777	0000	7777	7776	74
000161	74	57	57	57	57	7777	0000	7777	7776	75
000162	75	57	57	57	57	7777	0000	7777	7776	76
000163	76	57	57	57	57	7777	0000	7777	7776	00
NO PROGRAM ERRORS WERE DETECTED										
CPU-TIME IN CORRELATOR IS 20.50 USEC										

LISTING OF DATA-OUTPUT

Note that, due to the internal delay in the correlator, the first three program-counter values from the simulation are stripped.

For system stability test, the correlator was repetitively started 2 315 327⁸ times (operation time about 18 hours). After each start, the data from the correlator was automatically compared with a fixed table from the simulator. No program errors were detected.

LISTING OF TESTWORDS FROM THE CORRELATOR.

THIS LISTING WAS PRODUCED BY THE CORRELATOR SIMULATION PROGRAM -- CORRIO -- .

(THESE DATAWORDS WERE TRANSFERRED FROM THE CORRELATOR INTO THE COMPUTER BY MEANS OF DMA)

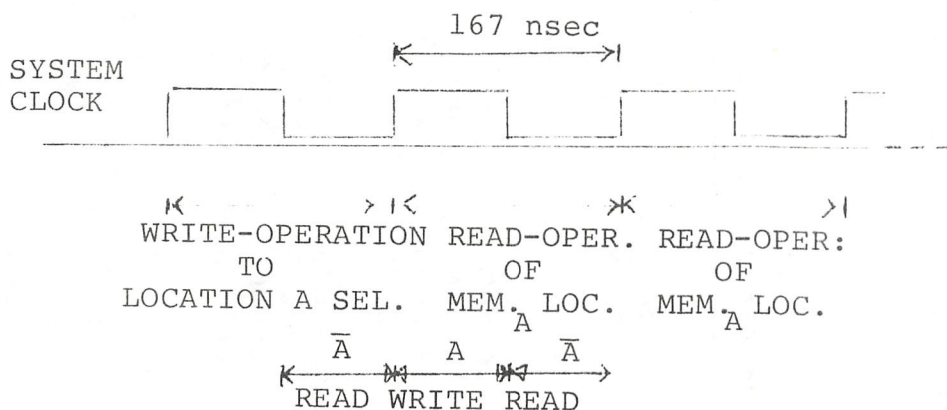
#SYSTEM-TEST S1:TEST ON PROGRAM-COUNTER MAPPING

0000	004000	005000	006000	007000	010000	011000	012000	013000
0010	014000	015000	016000	017000	020000	021000	022000	023000
0020	025000	027000	031000	032000	033000	034000	035000	036000
0030	036000	035000	034000	033000	037000	040000	040000	040000
0040	040000	040000	040000	040000	040000	040000	040000	040000
0050	040000	040000	040000	040000	040000	040000	040000	040000
0060	040000	040000	040000	040000	040000	040000	041000	042000
0070	043000	044000	045000	046000	047000	050000	047000	050000
0100	047000	050000	047000	050000	051000	052000	053000	054000
0110	055000	056000	057000	057000	057000	057000	057000	055000
0120	056000	057000	057000	057000	057000	055000	056000	057000
0130	057000	057000	055000	056000	057000	057000	055000	056000
0140	057000	055000	060000	061000	062000	063000	064000	065000
0150	066000	067000	070000	071000	072000	073000	074000	075000
0160	076000							

4.2 SYSTEM-TEST S2: BASIC LOADING OF THE RESULT-MEMORY

The testprogram S2 is constructed for separate test of the write-memory operation with data-values from the 32-bit accumulators. Both data-channels are operated in parallel and the main purpose of the testprogram is to detect possible errors in the generation of the write-address from processor APM or bit-errors in the result-memory itself. For each test-run of the program, all available memory-addresses and locations are referenced. With intension, a "worst-case" write mode is selected for also testing possible "cross-talk" loading, i.e. loading to memory locations not referenced.

The following time-diagram is selected for the write-operation (only one memory-write operation is sketched):



Bit-reversed address is selected at each side of the write-function.

The testprogram S2 consists of the following subroutines:

SUBROUTINE 1: (SAR=1) TEST OF LOADING -1 TO RESULT MEMORY

SUBROUTINE 2: (SAR=7) TEST OF LOADING 0 TO RESULT MEMORY

SUBROUTINE 3: (SAR=15) TEST OF LOADING THE TEST-SEQUENCE

TO THE RESULT MEMORY:

DATA-CHANNEL 1: x-values

DATA-CHANNEL 2: y-values

All subroutines use the following registers i data-field:

REGISTER NAME	INTERNAL ADDRESS	FUNCTION
STATUS-WORD=004020	1	SELECTS COMPUTER FOR STARTING THE CORRELATOR, AND TEST-SEQUENCE AT DATA INPUT
SAR=1	4	SELECT TEST OPTION
LCR1	22	NO OF RESULT-MEMORY LOCATIONS TO BE TESTED
LCR3	24	NO OF RESULT-MEMORY LOCATIONS TO BE TRANSFERRED TO COMPUTER
APM-STACK REG. 0	21,0	START-ADDRESS IN RES. MEMORY FOR TEST
APM-STACK REG. 1	21,1	ADDRESS-INCREMENT FOR WRITE
APM-STACK REG. 4	21,4	= 1777
APM-STACK REG. 17	21,17	START-ADDRESS IN RES. MEMORY FOR TRANSFER
APB-STACK REG. 0	20,0	START-ADDRESS IN TEST-MEMORY FOR TRANSFER TO RESULT MEMORY (ONLY SUB. 3)
APB-STACK REG. 1	20,1	ADDRESS-INCREMENT IN TEST-MEMORY
APB-STACK REG. 17	20,17	=154 → CONTAINING THE x-VALUE +1
APB-STACK REG. 16	20,16	=45 → CONTAINING THE y-VALUE 0

When LCR = 0, the selected subroutine is executed without DMA-transfer. On the following pages the test-results are presented, and for subroutine 3 also simulation results.

Long term stability tests:

Subroutine 1 started 1 002250 times

Subroutine 2 started 1 106453 times (subroutine 1 included at start)

Subroutine 3 started 3 201 483 times.

No errors were detected.

On the following pages, the listings results are shown.

* * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM-TEST S2: SUBROUTINE 1 -1 TO ALL MEM.LOCATIONS

* * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM-TEST S2: SUBROUTINE 2 0 TO ALL MEM. LOCATIONS

Subroutine 3 is executed with the CORRSIM arithmetical simulator (program 4) and on the following pages the simulation results are shown. A fully lk memory-test is performed and the correlator data print is given afterwards.

* * * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM TEST S2: SURROUTINE 3 2000 VALUES PROCESSED

0000:	177777	177705	177777	177734	0001:	177777	177712	177777	177644	0002:	177777	177721	177777	177766
0003:	000000	000045	000000	000076	0004:	177777	177736	177777	177652	0005:	177777	177776	177777	177701
0006:	177777	177741	177777	177714	0007:	000000	000073	000000	000052	0010:	000000	000066	000000	000047
0011:	000000	000070	177777	177751	0012:	000000	000136	102040	004152	0013:	177777	177617	177777	177705
0014:	177777	177725	177777	177770	0015:	000000	000074	000000	000006	0016:	000000	000003	000000	000035
0017:	177777	177715	000000	000055	0020:	000000	000006	000000	000056	0021:	104210	041475	177777	177771
0022:	177777	177741	000000	000030	0023:	000000	000074	000000	000054	0024:	177777	177730	177777	177773
0025:	177777	177742	000000	000047	0026:	177777	177660	177777	177655	0027:	177777	177766	000000	000077
0030:	000000	000036	177777	177601	0031:	000000	000111	177777	177745	0032:	000000	177725	177777	177764
0033:	177777	177713	177777	177752	0034:	177777	177711	177777	177664	0035:	000000	000023	000000	000011
0036:	000000	000106	000000	000142	0037:	000000	000015	000000	000047	0040:	177777	177744	177777	177664
0041:	000000	000005	177777	177750	0042:	000000	000134	000000	000155	0043:	177777	177744	075736	173575
0044:	177777	177702	000000	000050	0045:	000000	000140	000000	000000	0050:	000000	000030	000000	000013
0047:	177777	177740	177777	177732	0050:	000000	000012	000000	000013	0051:	177777	177763	177777	177702
0052:	177777	177752	000000	000023	0053:	000000	000026	000000	000024	0054:	000000	000024	177777	177707
0055:	177777	177770	177777	177664	0056:	177777	177742	000000	000006	0057:	000000	000102	000000	000017
0060:	000000	000022	077777	177770	0061:	004000	000012	000000	000000	0062:	177777	177766	177777	177714
0063:	000000	000002	000000	000031	0064:	000000	000057	000000	000076	0065:	177777	177740	000000	000120
0066:	000000	000036	000000	000034	0067:	000000	000120	177777	177674	0070:	177777	177764	177777	177772
0071:	000000	000005	177777	177736	0072:	177777	177723	000000	000024	0073:	177777	177772	000000	000050
0074:	000000	000056	000000	000000	0075:	000000	000030	000000	000022	0076:	177777	177767	000000	000104
0077:	177777	177735	177777	177736	0100:	177777	177743	177777	177757	0101:	000000	000061	177777	177712
0102:	177777	177713	000000	000045	0103:	177777	177664	000000	000037	0104:	177777	177765	000000	000061
0105:	177777	177720	000000	000013	0106:	000000	000032	177777	177731	0107:	000000	000003	000000	000011
0110:	000000	000135	177777	177745	0111:	000000	000000	177777	177755	0112:	177777	177746	177777	177710
0113:	000000	000067	000000	000000	0114:	000000	000004	000000	000031	0115:	000000	000144	000000	000042
0116:	000000	000002	177777	177740	0117:	177777	177660	000000	000023	0120:	177777	177677	000000	000003
0121:	000000	000103	177777	177765	0122:	000000	000056	000000	000033	0123:	000000	000141	000000	000000
0124:	177777	177752	177777	177761	0125:	000000	000006	000000	000105	0126:	000000	000020	000000	000057
0127:	177777	177722	177777	177775	0130:	177777	177671	000000	000056	0131:	177777	177672	177777	177777
0132:	177777	177762	000000	000053	0133:	000000	000063	177777	177746	0134:	000000	000032	000000	000017
0135:	177777	177726	177777	177713	0136:	177777	177722	177777	177727	0137:	000000	000023	000000	000057
0140:	000000	000111	000000	000033	0141:	000000	000144	000000	000010	0142:	177777	177676	000000	000107
0143:	177777	177731	000000	000162	0144:	177777	177744	000000	000020	0145:	000000	000007	000000	000020
0146:	000000	000003	177777	177734	0147:	177777	177740	000000	000032	0150:	177777	177726	177777	177770
0151:	177777	177762	000000	000072	0152:	177777	177714	000000	000041	0153:	000000	000120	177777	177777
0154:	000000	000001	000000	000024	0155:	000000	000066	177777	177767	0156:	177777	177740	177777	177771
0157:	000000	000003	000000	000046	0160:	177777	177777	177777	177713	0161:	000000	000036	000000	000012
0162:	000000	000010	000000	000020	0163:	177777	177712	177777	177772	0164:	177777	177771	177777	177765
0165:	000000	000111	000000	000046	0166:	000000	000033	177777	177731	0167:	000000	000150	000000	000072
0170:	000000	000074	000000	000015	0171:	000000	000024	177777	177774	0172:	000000	000000	000000	000056
0173:	000000	000021	000000	000121	0174:	000000	000023	000000	000177	0175:	000000	000051	000000	000042

0176:	17777	17727	17777	17777	17777	17777	00000	000025	17777	17777	17770	0200:	00000	000057	17777	17730
0201:	17777	17700	17777	17777	17777	17777	17777	17776	000000	000074	0203:	00000	000003	000000	00061	
0204:	17777	17761	17777	17777	17777	17777	17777	17776	000000	000074	0206:	17777	17775	17777	17731	
0207:	00000	000047	17777	17777	17777	17777	17777	17773	000000	000036	0210:	17777	177645	17777	177625	
0212:	00000	000101	00000	00000	00000	00000	00000	000020	17777	177750	0211:	00000	000026	17777	17731	
0215:	17777	17770	17777	17777	17777	17777	17777	17777	17777	17766	0214:	00000	000053	17777	17731	
0220:	17777	17731	00000	00000	00000	00000	00000	000060	17777	17777	0217:	00000	000054	17777	17712	
0223:	17777	17751	17777	17777	17777	17777	17777	177763	000000	000001	0222:	17777	17703	000000	00051	
0226:	00000	000076	00000	00000	00000	00000	00000	000145	17777	000037	0225:	00000	000135	17777	17732	
0231:	17777	17727	17777	17777	17777	17777	17777	17775	17777	17772	0230:	17777	177642	000000	00056	
0234:	17777	17763	00000	00000	00000	00000	00000	000021	17777	17771	0233:	17777	17735	17777	17740	
0237:	17777	17760	00000	00000	00000	00000	00000	000061	17777	17771	0236:	00000	000033	000000	00042	
0242:	17777	17763	00000	00000	00000	00000	00000	000111	17777	17764	0241:	17777	17764	17777	17750	
0245:	17777	17762	00000	00000	00000	00000	00000	000175	17777	17750	0244:	17777	17730	000000	00035	
0250:	00000	000105	17777	17777	17777	17777	17777	177601	000000	17722	0247:	00000	000073	17777	17702	
0256:	17777	17764	17777	17777	17777	17777	17777	177645	17777	17722	0252:	00000	000050	17777	17775	
0261:	17777	17765	17777	17777	17777	17777	17777	177704	17777	17732	0255:	00000	000133	17777	17723	
0264:	17777	17750	17777	17777	17777	17777	17777	177730	17777	17732	0260:	17777	17750	000000	00027	
0267:	00000	000050	17777	17777	17777	17777	17777	000024	000000	00050	0266:	17777	17716	000000	00027	
0272:	00000	000002	00000	00000	00000	00000	00000	000031	000000	00050	0271:	00000	000044	17777	17715	
0275:	00000	000025	00000	00000	00000	00000	00000	000034	17777	17736	0274:	00000	000000	17777	17742	
0300:	00000	000041	17777	17777	17777	17777	17777	17766	17777	17736	0277:	00000	000034	000000	00012	
0303:	00000	000067	17777	17777	17777	17777	17777	17770	000000	00071	0302:	17777	17731	000000	00027	
0306:	00000	000010	17777	17777	17777	17777	17777	17703	000000	00015	0305:	17777	17744	000000	00001	
0311:	17777	17777	00000	00000	00000	00000	00000	00016	17777	17765	0310:	00000	000065	000000	00050	
0314:	00000	000050	17777	17777	17777	17777	17777	17714	17777	17751	0313:	17777	17744	000000	000106	
0317:	00000	000041	00000	00000	00000	00000	00000	000007	000000	00010	0316:	00000	000024	000000	000132	
0322:	17777	17760	00000	00000	00000	00000	00000	000060	17777	00010	0321:	00000	000011	000000	00001	
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1307:	000000	000177	177777	177740	1310:	000000	000065	000000	000050	1311:	177777	177777	000000	000016
1312:	177777	177644	177777	177765	1313:	177777	177744	000000	000106	1314:	000000	000050	177777	177714
1315:	177777	177770	177777	177751	1316:	000000	000024	000000	000132	1317:	000000	000041	000000	000007
1320:	000000	000003	000000	000010	1321:	000000	000011	000000	000001	1322:	177777	177660	000000	000060
1323:	177777	177650	000000	000100	1324:	177777	177621	000000	000021	1325:	177777	177674	000000	000024
1326:	000000	000112	000000	000021	1327:	000000	000012	000000	000010	1330:	177777	177617	000000	000005
1331:	177777	177723	000000	000002	1332:	000000	000160	177777	177763	1333:	177777	177644	177777	177773
1334:	177777	177656	000000	000133	1335:	177777	177747	000000	000177	1336:	000000	000062	000000	000022
1337:	000000	000046	177777	177732	1340:	177777	177670	000000	000013	1341:	177777	177757	177777	177756
1342:	177777	177722	177777	177674	1343:	177777	177750	177777	177746	1344:	177777	177737	177777	177766
1345:	177777	177726	177777	177731	1346:	177777	177765	000000	000077	1347:	000000	000043	000000	000051
1350:	000000	000031	177777	177757	1351:	177777	177776	000000	000010	1352:	000000	000036	177777	177675
1353:	177777	177755	177777	177710	1354:	000000	000037	177777	177601	1355:	000000	000014	177777	177736
1356:	177777	177763	177777	177733	1357:	000000	000005	177777	177721	1360:	000000	000116	177777	177753
1361:	177777	177750	177777	177654	1362:	000000	000027	177777	177733	1363:	000000	000147	177777	177746
1364:	177777	177646	177777	177745	1365:	177777	177626	177777	177740	1366:	000000	000000	000000	000062
1367:	177777	177726	000000	000044	1370:	000000	000034	177777	177667	1371:	000000	000066	000000	000023
1372:	000000	000001	000000	000006	1373:	177777	177760	000000	000040	1374:	177777	177747	000000	000107
1375:	000000	000031	177777	177775	1376:	000000	000027	000000	000157	1377:	000000	000035	177777	177743
1400:	177777	177767	177777	177777	1401:	177777	177760	000000	000024	1402:	000000	000061	000000	000003
1403:	177777	177725	000000	000061	1404:	000000	000102	000000	000017	1405:	000000	000035	000000	000000
1406:	177777	177707	000000	000031	1407:	000000	000044	000000	000062	1410:	177777	177750	000000	000041
1411:	000000	000116	177777	177703	1412:	000000	000023	000000	000071	1413:	177777	177762	000000	000035
1414:	177777	177771	177777	177725	1415:	000000	000017	177777	177776	1416:	177777	177634	000000	000002
1417:	000000	000037	177777	177770	1420:	000000	000012	000000	000012	1421:	000000	000036	000000	000003

1422: 000000 000177 000000 000022
1425: 000000 000005 000000 000006
1430: 177777 177637 177777 177755
1433: 000000 000102 000000 000017
1436: 000000 000073 000000 000006
1441: 177777 177601 000000 000022
1444: 000000 000017 000000 000030
1447: 000000 000017 000000 000177
1452: 000000 000106 177777 177654
1455: 000000 000007 000000 000040
1460: 000000 000037 177777 177642
1463: 177777 177735 000000 000057
1466: 177777 177756 177777 177743
1471: 177777 177653 000000 000023
1474: 177777 177742 000000 000012
1477: 000000 000027 000000 000021
1502: 177777 177700 177777 177601
1505: 000000 000000 000000 000126
1510: 000000 000005 177777 177715
1513: 000000 000046 000000 000041
1516: 000000 000123 177777 177744
1521: 000000 000002 000000 000014
1524: 000000 000033 177777 177776
1527: 000000 000042 177777 177720
1532: 177777 177773 000000 000060
1535: 000000 000035 000000 000040
1540: 000000 000110 000000 000020
1543: 177777 177755 177777 177740
1546: 177777 177713 000000 000070
1551: 000000 000060 000000 000000
1554: 177777 177632 177777 177735
1557: 000000 000014 177777 177724
1562: 000000 000017 000000 000102
1565: 177777 177774 177777 177743
1570: 000000 000036 000000 000112
1573: 000000 000171 177777 177721
1576: 000000 000047 000000 000014
1601: 000000 000025 000000 000056
1604: 000000 000030 000000 000177
1607: 000000 000052 000000 000042
1612: 000000 000120 177777 177773
1615: 177777 177666 000000 000034
1620: 000000 000010 000000 000070
1623: 177777 177737 177777 177763
1423: 000000 000053 000000 000021
1426: 000000 000043 177777 177776
1431: 000000 000003 000000 000111
1434: 000000 000127 177777 177773
1437: 177777 177743 000000 000064
1442: 177777 177742 177777 177733
1445: 177777 177652 000000 000050
1450: 000000 000035 000000 000056
1453: 177777 177717 000000 000022
1456: 000000 000130 000000 000105
1461: 177777 177755 000000 000127
1464: 177777 177771 000000 000156
1467: 177777 177730 177777 177722
1472: 000000 000053 000000 000002
1475: 177777 177773 177777 177703
1500: 000000 000010 000000 000115
1503: 177777 177675 177777 177747
1506: 177777 177777 177777 177742
1511: 000000 000056 177777 177642
1514: 000000 000011 177777 177736
1517: 000000 000036 000000 000100
1522: 000000 000000 177777 177733
1525: 000000 000160 177777 177666
1530: 000000 000015 177777 177751
1533: 177777 177621 000000 000070
1536: 000000 000160 000000 000020
1541: 177777 177772 000000 000111
1544: 177777 177755 177777 177776
1547: 000000 000177 177777 177601
1552: 000000 000075 177777 177705
1555: 000000 000022 000000 000013
1560: 177777 177744 177777 177726
1563: 177777 177766 177777 177723
1566: 177777 177702 177777 177747
1571: 177777 177724 177777 177767
1574: 000000 000151 177777 177750
1577: 177777 177746 000000 000027
1602: 000000 000003 000000 000003
1605: 177777 177755 000000 000006
1610: 000000 000177 000000 000103
1613: 177777 177763 000000 000011
1616: 177777 177643 177777 177766
1621: 000000 000021 177777 177712
1624: 177777 177740 000000 000012
1424: 177777 177765 177777 177777
1427: 177777 177710 177777 177723
1432: 177777 177766 177777 177737
1435: 000000 000113 177777 177637
1440: 177777 177746 177777 177776
1443: 177777 177631 000000 000003
1446: 000000 000160 000000 000012
1451: 000000 000043 000000 000126
1454: 177777 177772 000000 000007
1457: 177777 177760 177777 177706
1462: 000000 000055 000000 000017
1465: 000000 000027 000000 000051
1470: 000000 000023 177777 177730
1473: 177777 177723 000000 000126
1476: 000000 000014 177777 177761
1501: 177777 177766 177777 177705
1504: 177777 177632 000000 000102
1507: 177777 177623 177777 177754
1512: 177777 177664 000000 000052
1515: 000000 000116 177777 177635
1520: 000000 000135 177777 177672
1523: 000000 000011 000000 000001
1526: 177777 177744 177777 177716
1531: 177777 177715 000000 000066
1534: 177777 177732 177777 177710
1537: 000000 000091 000000 000047
1542: 000000 000011 177777 177761
1545: 000000 000017 000000 000053
1550: 000000 000027 000000 000141
1553: 000000 000010 000000 000120
1556: 177777 177670 177777 177735
1561: 000000 000012 177777 177751
1564: 000000 000042 000000 000054
1567: 000000 000107 000000 000023
1572: 177777 177751 000000 000006
1575: 177777 177743 177777 177736
1600: 000000 000014 000000 000026
1603: 177777 177660 177777 177750
1606: 177777 177700 177777 177662
1611: 000000 000043 177777 177734
1614: 177777 177736 177777 177725
1617: 177777 177747 000000 000045
1622: 177777 177704 000000 000012
1625: 000000 000046 177777 177775

4.3 SYSTEM TEST S3: POWER PROFILE PROGRAM

The testprogram makes use of the main processing functions of the correlator. A listing of the testprogram can be found in Chapter 5. The program includes a subroutine for transferring data to the computer for comparison with a data-table generated from the simulator.

The following data-processing is tested:

$$\text{Data-channel 1: } K_r = \sum_{i=0}^{N-1} x_i^2 + y_i^2 \quad r = 0, 1, \dots, R$$

$$\text{Data-channel 2: } L_r = \sum_{i=0}^{N-1} x_i + y_i \quad r = 0, 1, \dots, R$$

The following correlator definitions are used:

REGISTER NAME	INTERNAL ADDRESS	FUNCTION
STATUS-WORD= 004020	1	SELECTS COMPUTER FOR STARTING THE CORRELATOR, AND TEST-SEQUENCE AT DATA INPUT
SAR=1	4	START POINTER FOR PROGRAM
LCR1	22	NO OF SAMPLES -2 IN RANGE GATE
LCR2	23	NO OF RANGE GATES -1
LCR3	24	NO OF 64-BITS WORDS TRANSFERRED TO COMPUTER AFTER EXECUTION
APB-STACK REG. 12	20,12,	RANGE GATE INCREMENT
- " - 13	20,13,	SAMPLE INCREMENT
- " - 14	20,14,	START-ADDRESS IN INPUT-MEMORY
APM-STACK REG. 13	21,13,	DATA INCREMENT IN RESULT-MEMORY
- " - 14	21,14,	START-ADDRESS IN RESULT-MEMORY

Parameters for loop-counters (LCR1, LCR2 and LCR3) together with address references in APB, APM can be set optionally by the programmer in a given test. In order to create the correct values for test-comparison, this can easily be done by using the ARITEST-option of the CORRSIM program. Power profile execution is simulated by using file no 2 and dependant on the actual definition of register, the program creates the correct values.

On the following pages this is shown for a simple example.

DIRECT SIMULATION OF CORRELATOR ARITHMETIC

START ON PROGRAM FOR POWER-PROFILE ESTIMATION

PARAMETERS DEFINED : NO. OF RANGE GATES PROCESSED : 16
 NO. OF SAMPLES IN RANGE GATE : 0001
 START ADDRESS IN BUFFER MEMORY : 000000
 INCREMENT : 000001
 OVERLAP BETWEEN RANGE GATES : 000177
 START ADDRESS IN RESULT-MEMORY : 0000
 INCREMENT : 0001

DISPLAY OF DATA AFTER 000001 STARTS

LOWER, UPPER LIMIT IN RESULT-MEMORY : 000000, 000017
 RES. MEM. LOCATION DATA1(MS) DATA1(LS) DATA2(MS) DATA2(LS)

0000	000455	033321	000000	005151
0001	000455	023041	000000	005325
0002	000455	053132	000000	005516
0003	000455	025765	000000	005211
0004	000455	032372	000000	005400
0005	000455	037352	000000	005452
0006	000455	022115	000000	005317
0007	000455	026011	000000	005223
0010	000455	044451	000000	005137
0011	000455	055614	000000	005552
0012.	000455	026754	000000	005372
0013	000455	023601	000000	005247
0014	000455	025201	000000	005223
0015	000455	027660	000000	005214
0016	000455	025622	000000	005272
0017	000455	023235	000000	005273

* * * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM-TEST S3: NO. OF SAMPLES 7777. NO. OF GATES 20

0000:	000455	033321	000000	005151	0001:	000455	023041	000000	005325	0002:	000455	033132	000000
0003:	000455	025765	000000	005211	0004:	000455	032372	000000	005400	0005:	000455	037352	000000
0006:	000455	022115	000000	005317	0007:	000455	026011	000000	005223	0010:	000455	044451	000000
0011:	000455	055614	000000	005552	0012:	000455	026754	000000	005372	0013:	000455	023601	000000
0014:	000455	025201	000000	005223	0015:	000455	027060	000000	005214	0016:	000455	025622	000000
0017:	000455	023235	000000	005273									

4.4 SYSTEM TEST S4: AUTOCORRELATION

The following data-processing is tested:

Data-channel 1:

$$R_{\ell,r} = \sum_{i=0}^{N-1-\ell} (x_i x_{i+\ell} + y_i y_{i+\ell})$$

$$I_{\ell,r} = \sum_{i=0}^{N-1-\ell} (x_i y_{i+\ell} - x_{i+\ell} y_i)$$

ℓ : lag index, $\ell=0,1,\dots,N-1$

r : range index, $r=0,1,\dots,R$

The following correlator definitions are used:

REGISTER NAME	INTERNAL ADDRESS	FUNCTION
STATUS-WORD=004020	1	SELECTS COMPUTER FOR STARTING THE CORRELATOR, AND TEST-SEQUENCE AT DATA INPUT
SAR=1	4	START POINTER FOR PROGRAM
LCR1	22	NO OF SAMPLES -1 IN RANGE GATE
LCR2	23	NO OF RANGE GATES -1
LCR3	24	NO OF 64-BITS WORDS TO BE DMA-TRANSFERRED
APB-STQCK REG 15	20,15	RANGE GATE INCREMENT AT INPUT
- " - 16	20,16	SAMPLE-INCREMENT AT INPUT
- " - 17	20,17	START-ADDRESS IN INPUT MEMORY
APM-STACK REG 13	21,13	DATA-INCREMENT FOR DMA-TRANSFER
- " - 14	21,14	START-ADDRESS IN RESULT MEM FOR DMA
- " - 15	21,15	MUST BE LCR 1+1 ALWAYS
- " - 16	21,16	DATA INCREMENT IN RES. MEM. DURING EXECUTION
- " - 17	21,17	START-ADDRESS IN RES.MEM.

Parameters can be set optionally by the programmer and values in a comparison test can be generated from ARITEST simulation using file 3.

On the following pages a test setup is shown. Values are first generated by the simulator and next the transferred values from the correlator are shown.

The parameters for the test are:

REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004020
START-ADDR, REGISTER = 07
REGISTER FOR LOOP-COUNTER 1 = 0032
REGISTER FOR LOOP-COUNTER 2 = 0046
REGISTER FOR LOOP-COUNTER 3 = 2000

APB-STACK :
REG.15=000010
REG.16=000001
REG.17=000000

APM-STACK :
REG.13=0001
REG.14=0000
REG.15=0033
REG.16=0001
REG.17=0000

DIRECT SIMULATION OF CORRELATOR ARITHMETIC

START ON PROGRAM FOR AUTOCORRELATION (ALL LAGS COMPUTED)

PARAMETERS DEFINED : NO. OF SAMPLES IN RANGE GATE : 0033
 NO. OF RANGE GATES : 0047
 START ADDRESS IN BUFFER : 000000
 SAMPLE-INCREMENT : 000001
 RANGE GATE-INCREMENT : 000010
 START ADDRESS IN RESULT-MEMORY : 0000
 LAG-INCREMENT : 0001
 RANGE GATE-INCREMENT : 0033

DISPLAY OF DATA AFTER 000001 STARTS

LOWER, UPPER LIMIT IN RESULT-MEMORY : 000000, 001777
 RES. MEM. LOCATION DATA1(MS) DATA1(LS) DATA2(MS) DATA2(LS)

0000	000002	047777	000000	000000
0001	177777	153326	177777	152451
0002	177777	166213	177777	141607
0003	177777	132120	177777	174103
0004	000000	015257	177777	150510
0005	177777	174151	177777	176570
0006	177777	176713	177777	167634
0007	000000	002311	177777	175574
0010	177777	121521	177777	124757
0011	177777	146563	000000	003071
0012	177777	172564	000000	031747
0013	000000	065556	177777	174725
0014	177777	141551	177777	160460
0015	177777	153316	177777	123214
0016	177777	114407	000000	037115
0017	177777	176145	000000	056325
0020	000000	013021	000000	010305
0021	177777	157120	000000	057416
0022	000000	005530	177777	162331
0023	177777	164312	177777	175277
0024	000000	027673	177777	161642
0025	000000	007507	000000	041267
0026	000000	011505	000000	003132
0027	000000	005512	177777	154736
0030	000000	006635	177777	137017
0031	000000	000133	177777	176157
0032	000000	005631	000000	001510

0033	000001	077634	000000	000000	000000
0034	177777	173272	000000	000000	056137
0035	177777	133213	177777	177777	164156
0036	000000	000444	000000	000000	030176
0037	177777	174222	177777	177777	167252
0040	000000	010753	177777	177777	132471
0041	000000	026621	177777	177777	153161
0042	177777	166675	000000	000000	032712
0043	177777	151467	000000	000000	017065
0044	177777	161661	177777	177777	157754
0045	000000	014021	177777	177777	163703
0046	177777	166070	000000	000000	005651
0047	177777	167247	000000	000000	005135
0050	000000	002742	000000	000000	032371
0051	177777	167426	177777	177777	172444
0052	000000	003510	177777	177777	152715
0053	177777	167646	177777	177777	160727
0054	000000	027604	000000	000000	017244
0055	000000	035754	000000	000000	026304
0056	177777	167314	177777	177777	153455
0057	000000	006724	000000	000000	002411
0060	177777	162224	000000	000000	020260
0061	000000	005232	177777	177777	164331
0062	000000	010506	000000	000000	015424
0063	177777	166044	177777	177777	171215
0064	000000	004730	177777	177777	166430
0065	000000	010210	000000	000000	011626
0066	000001	124235	000000	000000	000000
0067	000000	031304	000000	000000	021126
0070	177777	145777	177777	177777	173563
0071	177777	104775	177777	177777	140111
0072	177777	155647	177777	177777	143425
0073	000000	050547	177777	177777	130253
0074	000000	016074	000000	000000	033702
0075	177777	124457	177777	177777	155757
0076	177777	165273	177777	177777	165263
0077	000000	024447	177777	177777	163344
0100	000000	027753	000000	000000	003707
0101	177777	177745	177777	177777	165401
0102	177777	103566	000000	000000	002346
0103	177777	171043	177777	177777	146121
0104	000000	015642	000000	000000	007074
0105	000000	013116	000000	000000	007754
0106	177777	150070	000000	000000	025773

0107	177777	144171	000000	005146
0110	177777	157241	177777	175162
0111	000000	027301	000000	003325
0112	000000	032626	177777	163641
0113	000000	005243	000000	010272
0114	177777	167704	000000	004744
0115	177777	173156	000000	013470
0116	000000	004355	000000	002415
0117	177777	177206	177777	166005
0120	177777	175041	177777	172557
0121	000001	066740	000000	000000
0122	000000	047343	000000	007041
0123	000000	050576	177777	177327
0124	000000	003333	177777	176536
0125	177777	171040	177777	164705
0126	000000	013454	177777	144433
0127	000000	017410	177777	160376
0130	177777	163156	177777	146331
0131	000000	017746	000000	025604
0132	177777	173755	000000	033116
0133	000000	030074	177777	157611
0134	000000	022274	000000	015341
0135	000000	013053	177777	170550
0136	177777	162404	000000	012431
0137	000000	002227	000000	036737
0140	177777	157347	177777	160011
0141	000000	015602	177777	171764
0142	177777	174573	177777	171024
0143	000000	021676	000000	010700
0144	000000	012766	000000	032175
0145	000000	004016	000000	024236
0146	177777	177757	000000	013015
0147	177777	161071	000000	002524
0150	177777	170171	177777	175112
0151	177777	173673	177777	177413
0152	177777	173557	177777	176352
0153	000000	003055	177777	174734
0154	000002	026541	000000	000000
0155	177777	130654	177777	054717
0156	177777	160420	177777	171760
0157	177777	153437	177777	175517
0160	000000	003402	000000	016234
0161	000000	010577	177777	176033
0162	000000	041057	177777	175017

0163	177777	136013	177777	175070
0164	000000	057614	177777	163556
0165	000000	012503	177777	152433
0166	177777	167071	177777	173542
0167	177777	131326	000000	031644
0170	000000	022332	177777	172725
0171	177777	136566	177777	150743
0172	000000	020241	000000	006544
0173	177777	174175	177777	177216
0174	177777	157776	000000	013657
0175	000000	042363	000000	011341
0176	177777	155265	177777	177044
0177	000000	005723	000000	040730
0200	000000	062507	000000	010406
0201	177777	157647	177777	134034
0202	177777	160505	000000	000520
0203	177777	176502	000000	027311
0204	000000	013433	000000	014633
0205	000000	017444	000000	002411
0206	000000	001707	000000	002153
0207	000001	071027	000000	000000
0210	177777	143314	000000	013461
0211	000000	030044	000000	073512
0212	177777	176020	177777	134461
0213	177777	174553	000000	031412
0214	000000	020673	177777	171217
0215	177777	157712	177777	164353
0216	000000	021073	177777	161157
0217	000000	021731	000000	017374
0220	177777	164354	000000	007734
0221	177777	127573	177777	165603
0222	000000	014127	177777	143562
0223	177777	175266	177777	172662
0224	000000	000734	000000	007777
0225	177777	166066	000000	003447
0226	000000	002165	000000	002404
0227	177777	165571	177777	163073
0230	177777	147635	000000	026645
0231	000000	005444	177777	141515
0232	177777	142637	177777	171077
0233	000000	033254	000000	000751
0234	177777	146652	177777	154456
0235	000000	021045	000000	015234
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1177	177777	163655	177777	155572
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1207	177777	172720	000000	011056
1210	000002	071526	000000	000000
1211	000000	040325	000000	056121
1212	177777	132226	177777	163561
1213	177777	145650	000000	013133
1214	177777	135155	177777	172021
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1217	000000	017454	177777	137624
1220	000000	007302	177777	160533
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1222	000000	053757	177777	171461
1223	000000	045735	177777	173324
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1225	177777	132304	000000	024352
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1227	000000	007304	177777	133745
1230	177777	167157	177777	125031
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1241	000000	036000	177777	161710
1242	177777	163540	000000	013322
1243	000002	101667	000000	000000
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1245	000000	027474	000000	033033
1246	000000	005214	000000	010415
1247	177777	061440	177777	174034
1250	177777	125433	000000	124763
1251	177777	136365	177777	177011
1252	000000	023042	000000	003642
1253	177777	177776	177777	163462
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1257	177777	122534	177777	157137
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1261	177777	116471	000000	000735
1262	177777	123570	000000	020351
1263	000000	022206	000000	032567
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1265	000000	055501	000000	003432
1266	000000	004237	177777	124272
1267	000000	003554	177777	160311
1270	000000	026335	000000	010427
1271	177777	174356	177777	166544
1272	177777	157640	000000	017654
1273	177777	177243	177777	174344
1274	177777	170267	177777	177655
1275	000000	002417	000000	007276
1276	000002	031661	000000	000000
1277	000000	035320	000000	010025
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1201	000000	031335	177777	172516
1202	177777	173413	000000	050601
1203	177777	060570	177777	166426
1204	177777	161326	177777	144747
1205	177777	165640	000000	022170
1206	177777	161700	000000	030621
1307	000000	030762	177777	123607
1310	000000	006416	000000	011524
1311	177777	151477	000000	022077
1312	000000	054041	177777	115305
1313	000000	063374	177777	074314
1314	177777	171737	000000	023652
1315	177777	165077	177777	172556
1316	000000	034157	000000	013212
1317	177777	171502	000000	024532
1320	177777	102744	000000	026704
1321	177777	174122	177777	176040
1322	000000	006610	177777	175567
1323	000000	001457	177777	173543
1324	177777	172446	177777	160767
1325	177777	174740	000000	004641
1326	000000	004624	000000	007531
1327	177777	176622	177777	174761
1330	177777	170756	177777	170530
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1332	000000	036651	000000	107323

1333	177777	160661	177777	165735
1334	177777	165516	177777	166531
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1337	177777	144567	177777	151331
1340	000000	010557	177777	174463
1341	000000	002255	000000	002076
1342	177777	174156	000000	027212
1343	177777	115333	177777	165044
1344	000000	026006	177777	101774
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1346	000000	011533	177777	172254
1347	000000	010044	177777	150505
1350	000000	043415	177777	156134
1351	000000	024424	177777	175725
1352	177777	155673	177777	156714
1353	177777	176644	177777	175121
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1356	177777	157203	000000	006267
1357	177777	176342	177777	167513
1360	177777	172721	177777	162472
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1362	177777	176560	177777	172354
1363	000000	001553	177777	176221
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1365	000000	013654	000000	143461
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1370	000000	014212	177777	127211
1371	177777	164721	000000	007123
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1374	000000	041677	177777	124355
1375	000000	067057	000000	036507
1376	000000	003314	177777	162771
1377	000000	054705	000000	047305
1400	177777	142054	000000	047750
1401	177777	170517	000000	016721
1402	177777	145277	177777	123757
1403	000000	036516	177777	127132
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1405	000000	077430	000000	024363
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1407	177777	167223	177777	172655
1410	000000	001774	177777	171742
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1412	000000	003347	000000	024735
1413	177777	171434	000000	004547
1414	177777	172472	177777	165552
1415	177777	174461	177777	174667
1416	000000	026425	177777	176355
1417	000001	154121	000000	000000
1420	177777	154434	177777	127305
1421	177777	177563	000000	017400
1422	177777	173252	177777	166525
1423	177777	117510	000000	016661
1424	177777	154435	000000	015052
1425	177777	136376	000000	024605
1426	000000	045545	000000	002570
1427	000000	065775	177777	146155
1430	177777	171504	177777	156243
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1432	177777	154431	177777	141523
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1435	177777	153014	000000	031047
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1437	177777	154167	177777	137125
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1441	000000	026504	177777	150754
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1443	000000	010107	000000	030176
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1445	177777	171230	000000	015405
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1447	177777	163623	177777	174650
1450	177777	173020	177777	174335
1451	177777	175057	000000	000762
1452	000002	025334	000000	000000
1453	000000	020777	177777	161132
1454	177777	150533	177777	156134
1455	177777	136426	000000	045710
1456	177777	150460	000000	003667
1457	177777	173310	177777	156713
1460	000000	000031	177777	173464
1461	000000	004702	177777	161543
1462	177777	074414	177777	141201

1463	177777	165747	000000	007145
1464	000000	034206	000000	032017
1465	000000	111711	177777	143121
1466	177777	172214	177777	130106
1467	177777	161642	000000	017734
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1477	000000	046275	177777	175012
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1501	177777	174604	177777	160402
1502	177777	161306	000000	013150
1503	177777	151273	177777	177425
1504	177777	167233	000000	013743
1505	000001	136751	000000	000000
1506	177777	174751	000000	032156
1507	177777	062662	177777	154326
1510	000000	022363	000000	044057
1511	000000	050221	000000	012251
1512	177777	164272	177777	114314
1513	000000	021564	177777	142074
1514	000000	006576	000000	061473
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1516	177777	163776	177777	152450
1517	000000	013332	177777	170505
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1521	177777	172745	000000	001251
1522	000000	010427	000000	021551
1523	177777	167570	000000	000642
1524	177777	166440	177777	163160
1525	177777	155756	177777	164655
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1541	000000	033432	000000	017172
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1543	177777	124306	177777	125733
1544	177777	144537	177777	164326
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1550	177777	165145	177777	155511
1551	000000	010566	000000	016264
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1553	000000	003051	177777	162416
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1561	177777	154350	000000	006403
1562	000000	006242	177777	171220
1563	000000	004270	000000	023206
1564	000000	013722	177777	162724
1565	000000	017352	177777	171333
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1567	000000	002724	000000	004642
1570	000000	000352	000000	017703
1571	177777	176077	177777	177502
1572	177777	177273	000000	002715
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1601	000000	042351	177777	152636
1602	000000	012516	177777	150744
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1604	177777	163410	000000	035150
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1607	000000	025424	177777	171535
1610	177777	165516	000000	025152
1611	177777	165145	000000	024712
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1613	000000	011676	177777	171503
1614	000000	003662	177777	155260
1615	000000	017031	000000	044337
1616	177777	174323	000000	047533
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1620	177777	170661	000000	053204
1621	177777	163023	000000	016002
1622	000000	014741	000000	011451
1623	000000	032031	000000	027331
1624	000000	043676	000000	032550
1625	000000	017123	000000	023003
1626	000002	012055	000000	000000
1627	177777	105667	177777	066641
1630	000000	013077	000000	017542
1631	177777	160714	177777	126524
1632	000000	004430	177777	175615
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1635	177777	123441	000000	005273
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1637	177777	151612	177777	167710
1640	000000	006462	000000	002003
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1642	000000	043255	000000	011475
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1644	000000	030714	000000	033623
1645	177777	172150	177777	153242
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1650	177777	127313	000000	012676
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1660	177777	172613	000000	004316
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1662	000000	010570	000000	030352
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1665	177777	172217	000000	004614
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1667	000000	014333	000000	014454
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1672	177777	161535	000000	024626
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1712	177777	177273	000000	001102
1713	177777	176257	177777	175636
1714	000002	100166	000000	000000
1715	000000	101427	000000	105143
1716	177777	065136	177777	136475
1717	000000	030154	177777	137146
1720	000000	065363	000000	025270
1721	000000	007005	177777	164725
1722	177777	135206	177777	066775
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1726	000000	052634	177777	134544
1727	000000	020624	000000	016322
1730	177777	125634	000000	035243
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1732	000000	116642	177777	110216
1733	000000	017633	177777	174711
1734	177777	127617	177777	142416
1735	000000	000650	177777	170016
1736	000000	050762	000000	007321
1737	177777	171754	000000	032333
1740	177777	136051	177777	166413
1741	000000	013335	177777	145433
1742	000000	023747	000000	015152

1743	177777	176042	177777	170050
1744	000000	002531	177777	155403
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1746	177777	165732	000000	003344
1747	000001	172617	000000	000000
1750	000000	042151	000000	005327
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1752	000000	076751	177777	177452
1753	177777	165206	177777	166146
1754	000000	043530	000000	002277
1755	000000	053573	000000	014134
1756	000000	063735	000000	006304
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1760	177777	175766	000000	043507
1761	177777	147541	000000	012600
1762	177777	134750	000000	000057
1763	000000	014574	177777	155631
1764	177777	137211	177777	166242
1765	177777	173524	177777	162626
1766	177777	153673	177777	177051
1767	177777	112571	177777	170617
1770	177777	162131	177777	150720
1771	177777	136474	177777	161736
1772	177777	156557	177777	147001
1773	177777	165765	177777	160106
1774	177777	175615	177777	174335
1775	177777	171154	177777	164554
1776	177777	154057	177777	176507
1777	177777	176773	177777	156517

* * * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM-TEST S4:AUTOCORRELATION

0000:	000002	047777	000000	000000	0001:	177777	153326	177777	152451	0002:	177777	166213	177777	141607
0003:	177777	132120	177777	174103	0004:	000000	015257	177777	150510	0005:	177777	174151	177777	176570
0006:	177777	176713	177777	167634	0007:	000000	002311	177777	175574	0010:	177777	121521	177777	124757
0011:	177777	146563	000000	003071	0012:	177777	172564	000000	031747	0013:	000000	065556	177777	174725
0014:	177777	141551	177777	160460	0015:	177777	153316	177777	123214	0016:	177777	114407	000000	037115
0017:	177777	176145	000000	056325	0020:	000000	013021	000000	010305	0021:	177777	157120	000000	057416
0022:	000000	005530	177777	162331	0023:	177777	164312	177777	175277	0024:	000000	027673	177777	161642
0025:	000000	007507	000000	041267	0026:	000000	011505	000000	003132	0027:	000000	005512	177777	154736
0030:	000000	006635	177777	137017	0031:	000000	000133	177777	176157	0032:	000000	005631	000000	001510
0033:	000001	077634	000000	000000	0034:	177777	173272	000000	056137	0035:	177777	133213	177777	164156
0036:	000000	000444	000000	030176	0037:	177777	174222	177777	167252	0040:	000000	010753	177777	132471
0041:	000000	026621	177777	153161	0042:	177777	166675	000000	032712	0043:	177777	151467	000000	017065
0044:	177777	161661	177777	157754	0045:	000000	014021	177777	163703	0046:	177777	166070	000000	005651
0047:	177777	167247	000000	005135	0050:	000000	002742	000000	032371	0051:	177777	167426	177777	172444
0052:	000000	003510	177777	152715	0053:	177777	167646	177777	160727	0054:	000000	027604	000000	017244
0055:	000000	035754	000000	026304	0056:	177777	167314	177777	153455	0057:	000000	006724	000000	002411
0060:	177777	162224	000000	020260	0061:	000000	005232	177777	164331	0062:	000000	010506	000000	015424
0063:	177777	166044	177777	171215	0064:	000000	004730	177777	166430	0065:	000000	010210	000000	011626
0066:	000001	124235	000000	000000	0067:	000000	031304	000000	021126	0070:	177777	145777	177777	173563
0071:	177777	104775	177777	140111	0072:	177777	155647	177777	143425	0073:	000000	050547	177777	130253
0074:	000000	016074	000000	033702	0075:	177777	124457	177777	155757	0076:	177777	165273	177777	165263
0077:	000000	024447	177777	163344	0100:	000000	027753	000000	003707	0101:	177777	177745	177777	165401
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0105:	000000	013116	000000	007754	0106:	177777	150070	000000	025773	0107:	177777	144171	000000	005146
0110:	177777	157241	177777	175162	0111:	000000	027301	000000	003325	0112:	000000	032626	177777	163641
0113:	000000	005243	000000	010272	0114:	177777	167704	000000	004744	0115:	177777	173156	000000	013470
0116:	000000	004355	000000	002415	0117:	177777	177206	177777	166005	0120:	177777	175041	177777	172557
0121:	000001	066740	000000	000000	0122:	000000	047343	000000	007041	0123:	000000	050576	177777	177327
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1257:	177777	122534	177777	157137	1260:	177777	173174	000000	011122	1261:	177777	116471	000000	000735
1262:	177777	123570	000000	020351	1263:	000000	022206	000000	032567	1264:	177777	173333	177777	113545
1265:	000000	055501	000000	003432	1266:	000000	004237	177777	124272	1267:	000000	003554	177777	160311
1270:	000000	026335	000000	010427	1271:	177777	174356	177777	166544	1272:	177777	157640	000000	017654
1273:	177777	177243	177777	174344	1274:	177777	170267	177777	177655	1275:	000000	002417	000000	007276
1276:	000002	031061	000000	000000	1277:	000000	035320	000000	010025	1300:	177777	104654	000000	005572
1301:	000000	031335	177777	172516	1302:	177777	173413	000000	050601	1303:	177777	060570	177777	166426
1304:	177777	161326	177777	144747	1305:	177777	165640	000000	022170	1306:	177777	161700	000000	030621
1307:	000000	030762	177777	123607	1310:	000000	006416	000000	011524	1311:	177777	151477	000000	022077
1312:	000000	054041	177777	115305	1313:	000000	063374	177777	074314	1314:	177777	171737	000000	023652
1315:	177777	165077	177777	172556	1316:	000000	034157	000000	013212	1317:	177777	171502	000000	024532
1320:	177777	102744	000000	026704	1321:	177777	174122	177777	176040	1322:	000000	006610	177777	175567
1323:	000000	001457	177777	173543	1324:	177777	172446	177777	160767	1325:	177777	174740	000000	004641
1326:	000000	004624	000000	007531	1327:	177777	176622	177777	174761	1330:	177777	170756	177777	170530
1331:	000001	133625	000000	000000	1332:	000000	036651	000000	107323	1333:	177777	160661	177777	165735
1334:	177777	165516	177777	166531	1335:	000000	015072	000000	003661	1336:	177777	162715	000000	042162
1337:	177777	144567	177777	151331	1340:	000000	010557	177777	174463	1341:	000000	002255	000000	002076
1342:	177777	174156	000000	027212	1343:	177777	115333	177777	165044	1344:	000000	026006	177777	101774
1345:	000000	035476	177777	177132	1346:	000000	011533	177777	172254	1347:	000000	010044	177777	150505
1350:	000000	043415	177777	156134	1351:	000000	024424	177777	175725	1352:	177777	155673	177777	156714
1353:	177777	176644	177777	175121	1354:	177777	173175	000000	005645	1355:	177777	177766	000000	023763
1356:	177777	157203	000000	006267	1357:	177777	176342	177777	167513	1360:	177777	172721	177777	162472
1361:	000000	001344	177777	161063	1362:	177777	176560	177777	172354	1363:	000000	001553	177777	176221
1364:	000002	011246	000000	000000	1365:	000000	013654	000000	143461	1366:	000000	020760	000000	073521
1367:	177777	102340	000000	053767	1370:	000000	014212	177777	127211	1371:	177777	164721	000000	007123
1372:	000000	034415	177777	123110	1373:	177777	176414	000000	023205	1374:	000000	041677	177777	124355
1375:	000000	067057	000000	036507	1376:	000000	003314	177777	162771	1377:	000000	054705	000000	047305
1400:	177777	142054	000000	047750	1401:	177777	170517	000000	016721	1402:	177777	145277	177777	123757
1403:	000000	036516	177777	127132	1404:	000000	032221	177777	173033	1405:	000000	077430	000000	024363
1406:	177777	162730	000000	046376	1407:	177777	167223	177777	172655	1410:	000000	001774	177777	171742
1411:	000000	030050	000000	002317	1412:	000000	003347	000000	024735	1413:	177777	171434	000000	004547
1414:	177777	172472	177777	165552	1415:	177777	174461	177777	174667	1416:	000000	026425	177777	176355
1417:	000001	154121	000000	000000	1420:	177777	154434	177777	127305	1421:	177777	177563	000000	017400

1422:	177777	173252	177777	166525	1423:	177777	117510	000000	016661	1424:	177777	154435	000000	015052
1425:	177777	136376	000000	024605	1426:	000000	045545	000000	002570	1427:	000000	065775	177777	146155
1430:	177777	171504	177777	156243	1431:	000000	026775	000000	015114	1432:	177777	154431	177777	141523
1433:	177777	153303	000000	060547	1434:	177777	164414	000000	010200	1435:	177777	153014	000000	031047
1436:	000000	012251	177777	166311	1437:	177777	154167	177777	137125	1440:	000000	004712	000000	005662
1441:	000000	026504	177777	150754	1442:	177777	162724	000000	005426	1443:	000000	010107	000000	030176
1444:	000000	007604	177777	175212	1445:	177777	171230	000000	015405	1446:	177777	171366	177777	154400
1447:	177777	163623	177777	174650	1450:	177777	173020	177777	174335	1451:	177777	175057	000000	000762
1452:	000002	025334	000000	000000	1453:	000000	020777	177777	161132	1454:	177777	150533	177777	156134
1455:	177777	136426	000000	045710	1456:	177777	150460	000000	003667	1457:	177777	173310	177777	156713
1460:	000000	000031	177777	173464	1461:	000000	004702	177777	161543	1462:	177777	074414	177777	141201
1463:	177777	165747	000000	007145	1464:	000000	034206	000000	032017	1465:	000000	111711	177777	143121
1466:	177777	172214	177777	130106	1467:	177777	161642	000000	017734	1470:	177777	131664	000000	012150
1471:	177777	123576	000000	027212	1472:	000000	021430	000000	011726	1473:	177777	171111	000000	004414
1474:	177777	174032	177777	134662	1475:	177777	165707	177777	175365	1476:	000000	010073	000000	004265
1477:	000000	046275	177777	175012	1500:	000000	020023	177777	175070	1501:	177777	174604	177777	160402
1502:	177777	161306	000000	013150	1503:	177777	151273	177777	177425	1504:	177777	167233	000000	013743
1505:	000001	136751	000000	000000	1506:	177777	174751	000000	032156	1507:	177777	062662	177777	154326
1510:	000000	022363	000000	044057	1511:	000000	050221	000000	012251	1512:	177777	164272	177777	114314
1513:	000000	021564	177777	142074	1514:	000000	006576	000000	061473	1515:	177777	146724	000000	006121
1516:	177777	163776	177777	152450	1517:	000000	013332	177777	170505	1520:	177777	155765	000000	016246
1521:	177777	172745	000000	001251	1522:	000000	010427	000000	021551	1523:	177777	167570	000000	000642
1524:	177777	166440	177777	163160	1525:	177777	155756	177777	164655	1526:	000000	043325	000000	020725
1527:	000000	053100	000000	032310	1530:	177777	155725	177777	154236	1531:	177777	160111	177777	174035
1532:	000000	000251	000000	043655	1533:	000000	022340	177777	164702	1534:	000000	023462	177777	141514
1535:	000000	007430	000000	012730	1536:	177777	175152	000000	027646	1537:	177777	175154	177777	176414
1540:	000001	135553	000000	000000	1541:	000000	033432	000000	017172	1542:	177777	165064	000000	000430
1543:	177777	124306	177777	125733	1544:	177777	144537	177777	164326	1545:	000000	036257	177777	150206
1546:	177777	172371	000000	035762	1547:	177777	151300	177777	134244	1550:	177777	165145	177777	155511
1551:	000000	010566	000000	016264	1552:	000000	022446	177777	177264	1553:	000000	003051	177777	162416
1554:	177777	151755	177777	147604	1555:	000000	013100	177777	140553	1556:	177777	157661	000000	002333
1557:	177777	155446	000000	040431	1560:	177777	145222	000000	017120	1561:	177777	154350	000000	006403
1562:	000000	006242	177777	171220	1563:	000000	004270	000000	023206	1564:	000000	013722	177777	162724
1565:	000000	017352	177777	171333	1566:	000000	022674	000000	002062	1567:	000000	002724	000000	004642
1570:	000000	000352	000000	017703	1571:	177777	176077	177777	177502	1572:	177777	172723	000000	002715
1573:	000001	126452	000000	000000	1574:	000000	072164	000000	005765	1575:	000000	060504	000000	003745
1576:	177777	177010	177777	165254	1577:	000000	010254	177777	135106	1600:	000000	030737	177777	121432
1601:	000000	042351	177777	152636	1602:	000000	012516	177777	150744	1603:	000000	006572	000000	033365
1604:	177777	163410	000000	035150	1605:	000000	023243	177777	167002	1606:	000000	000444	000000	006544
1607:	000000	025424	177777	171535	1610:	177777	165516	000000	025152	1611:	177777	165145	000000	024712
1612:	177777	163676	177777	166547	1613:	000000	011676	177777	171503	1614:	000000	003662	177777	155260
1615:	000000	017031	000000	044337	1616:	177777	174323	000000	047533	1617:	177777	165515	000000	055253
1620:	177777	170661	000000	053204	1621:	177777	163023	000000	016002	1622:	000000	014741	000000	011451
1623:	000000	032031	000000	027331	1624:	000000	043676	000000	032550	1625:	000000	017123	000000	023003

1626: 000002 012055 000000 000000
1631: 177777 160714 177777 126524
1634: 000000 015424 177777 156103
1637: 177777 151612 177777 167710
1642: 000000 043255 000000 011475
1645: 177777 172150 177777 153242
1650: 177777 127313 000000 012676
1653: 177777 162600 177777 153456
1656: 000000 004536 000000 006522
1661: 000001 142202 000000 000000
1664: 177777 153646 177777 121260
1667: 000000 014333 000000 014454
1672: 177777 161535 000000 024626
1675: 000000 010130 000000 011515
1700: 177777 166745 177777 176123
1703: 177777 176267 177777 146734
1706: 177777 173776 177777 164452
1711: 000000 000664 177777 154534
1714: 000002 100166 000000 000000
1717: 000000 030154 177777 137146
1722: 177777 135206 177777 066775
1725: 000000 101623 000000 024675
1730: 177777 125634 000000 035243
1733: 000000 017633 177777 174711
1736: 000000 050762 000000 007321
1741: 000000 013335 177777 145433
1744: 000000 002531 177777 155403
1747: 000001 172917 000000 000000
1752: 000000 076751 177777 177452
1755: 000000 053573 000000 014134
1760: 177777 175766 000000 043507
1763: 000000 014574 177777 155631
1766: 177777 153673 177777 177051
1771: 177777 136474 177777 161736
1774: 177777 175615 177777 174335
1777: 177777 176773 177777 156517

1627: 177777 105667 177777 066641
1632: 000000 004430 177777 175615
1635: 177777 123441 000000 005273
1640: 000000 006462 000000 002003
1643: 177777 114471 177777 150231
1646: 177777 167610 000000 040051
1651: 000000 016475 000000 036337
1654: 000000 005660 000000 013574
1657: 177777 171660 177777 161105
1662: 000000 010570 000000 030352
1665: 177777 172217 000000 004614
1670: 000000 017456 177777 164151
1673: 177777 130263 000000 014575
1676: 000000 022360 000000 033072
1701: 000000 003275 177777 132321
1704: 000000 006655 177777 156170
1707: 177777 171413 177777 172323
1712: 177777 177273 000000 001102
1715: 000000 101427 000000 105143
1720: 000000 065363 000000 025270
1723: 000000 037067 177777 141026
1726: 000000 052634 177777 134544
1731: 000000 001276 177777 072406
1734: 177777 127617 177777 142416
1737: 177777 171754 000000 032333
1742: 000000 023747 000000 015152
1745: 177777 173041 177777 177112
1750: 000000 042151 000000 005327
1753: 177777 165206 177777 166146
1756: 000000 063733 000000 006304
1761: 177777 147541 000000 012600
1764: 177777 137211 177777 166242
1767: 177777 112571 177777 170617
1772: 177777 156557 177777 147001
1775: 177777 171154 177777 164554

1630: 000000 013077 000000 017542
1633: 177777 170400 177777 173367
1636: 000000 047500 177777 172342
1641: 177777 142257 000000 012156
1644: 000000 030714 000000 033623
1647: 000000 017305 000000 010257
1652: 000000 070373 000000 006767
1655: 000000 017133 177777 154540
1660: 177777 172613 000000 004316
1663: 000000 017304 000000 040441
1666: 000000 063310 000000 002773
1671: 000000 033664 000000 032424
1674: 000000 007501 177777 131173
1677: 177777 156770 000000 021640
1702: 177777 177303 177777 174136
1705: 000000 023521 000000 003373
1710: 177777 154600 177777 155041
1713: 177777 176257 177777 175636
1716: 177777 065136 177777 136475
1721: 000000 007005 177777 164725
1724: 000000 102007 000000 104315
1727: 000000 020624 000000 016322
1732: 000000 116642 177777 110216
1735: 000000 000650 177777 170016
1740: 177777 136051 177777 166413
1743: 177777 176042 177777 170050
1746: 177777 165732 000000 003344
1751: 000000 046022 000000 050235
1754: 000000 043530 000000 002277
1757: 000000 000023 000000 050037
1762: 177777 134750 000000 000057
1765: 177777 173524 177777 162626
1770: 177777 162131 177777 150720
1773: 177777 165765 177777 160106
1776: 177777 154057 177777 176507

4.5 EXTENDED TESTS

The given system tests can, by use of the CORRSIM program, be repeatedly executed and automatically tested against a fixed simulation-table. In order to achieve this, each execution of the microprogram must be ended with a reset of the internal flip-flops controlling the accumulation function of the arithmetical module. This step must be done by the programmer.

The simulator can also produce comparison-data for a fixed number of accumulation periods. By modification of the microprograms, using a loop-counter for counting the number of accumulations before the DMA-part of the program is started, the CORRSIM test can include testing the correlator in accumulation mode.

The following example will illustrate this:

EX. A. TEST OF AUTOCORRELATION IN ACCUMULATING MODE

System test S4 is modified by using loop-counter 3 for counting the number of program-executions. This is done by making the following program-modifications on S4:

- I) Change program instruction 0 to 40,0,4,4,4,4,4,2,0,0,
- II) Change program instruction 23 to 70,0,4,0,0,0,0,1,0,0,
- III) Change program instruction 24 to 74,4,6,7,0,0,0,0,0,0,
- IV) Change accum. instruction 25 to 1,0,0,1,0,1,0,

With these corrections loop-counter 3 restarts the autocorrelation program until the value 0 is reached, then the DMA-cycle is initiated and the accumulation mode is reset.

On the following pages an example is given. The number of restarts is 1777.

5. AVAILABLE CORRSIM FILES FOR CORRELATOR TESTING

The following files are available:

HARDWARE TESTS	H1:	TESTS ON INTERNAL PROGRAM EXECUTION
	H2:	TESTS OF ARITHMETICAL FUNCTIONS ON ADDRESS PROCESSORS APM, APM.
	H3:	TESTS ON REGISTER STACK LOADING AND ACCUMULATION IN APB, APM
	H4:	TESTS ON MULTIPLIERS AND PARTIAL ACCUMULATORS
	H5:	TESTS ON 32-BITS ACCUMULATORS
	H6:	TESTS ON INTERNAL OPERATIONS
SYSTEM TESTS	S1:	TESTS ON INTERNAL EXECUTION
	S2:	TESTS ON LOADING THE RESULT MEMORY
	S3:	POWER PROFILE TESTING

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.j. Alker

Date: August 1978

Program name: H1: TESTS ON INTERNAL PROGRAM EXECUTION **File-name (NORD-10):** (CORR)H1: DATA

Program version: II (modified microprogram from system test S1)

Functional description:

The program-counter is mapped through the program memory and during execution, commonly used program instructions are tested. If the program-counter reached location 67 after 10152 statement-cycles, no errors have been occurring.

Start-address for program: 1

Program-memory locations used: 1 - 67

Parameters stored: (fixed setup)

Register name	Register address	Parameter
STATUS-REG.	1,	004000 for computer control of start-signal
SAR-REG.	4,	1
LOOP-COUNTER	1 22,	5
- " -	2 23,	4
- " -	3 24,	1

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker
Date: August 1978

Program name: H2: TESTS OF ARITHMETI-
CAL FUNCTION ON ADDRESS-PROCESSORS **File-name (NORD-10):** (CORR)H2: DATA
Program version:

Functional description:

DISPLAY OF REGISTER-STACK LOADING AND PROCESSOR
ADD/SUBTRACT FUNCTIONS ARE EXECUTED.

THE TWO ADDRESS PROCESSORS APB AND APM ARE OPERATED IN PARALLEL

Start-address for program: 1
Program-memory locations used: 1-71.

Parameters stored:

Register name	Register address	Parameter
STATUS-REG.	1,	004000
SAR-REG.	4,	1
APB-STACK	20,1, to 20,17,	OPTIONAL VALUES FOR TEST
APM-STACK	21,1, to 21.17,	OPTIONAL VALUES FOR TEST

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: H3: TESTS ON STACK-LOAD AND ACC. IN APB,APM **File-name (NORD-10):** H3: DATA

Program version:

Functional description:

- SUBROUTINE 1: TEST OF ACCUMULATION
- SUBROUTINE 2: TEST OF INTERNAL STACK-LOADING
- SUBROUTINE 3: (APB ONLY) LOOP-COUNTER REFERENCE FOR STACK:

Start-address for program: SUB1: 1, SUB2:13, SUB3:63.

Program-memory locations used: SUB1:1-12
 SUB2:13-62
 SUB3:63-70

Parameters stored:

Register name	Register address	Parameter
STATUS-REG.	1,	004000
SAR-REG.	4,	1,13 or 63
SUB1: LOOP-COUNTER 1,2,3	22,23,24	NO OF ACCUMULATIONS
STACK-REG. 0	20,0, and 21,0	STARTVALUE FOR ACC.
STACK-REG. 1	20,1, and 21,1	INCREMENT VALUE FOR ACC.
SUB2: STACK-REG.	20,0,-20,17, and 21,0,-21,17,	OPTIONAL VALUES FOR INTERNAL LOAD TEST
SUB3: APB-STACK 17	20,17	20: VALUE LOADED TO LCRI.
APB-STACK 0-16	20,0,-20,17,	OPTIONAL VALUES FOR DISPLAY

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker
Date: August 1978

Program name: H4: TESTS ON MULTIPLIERS AND PARTIAL ACCUMULATORS **File-name (NORD-10):** (CORR)H4: DATA

Program version: II (modified microprogram from system test)

Functional description:

TESTS THE FOUR HARDWARE MULTIPLIERS AND ADD/SUBTRACT-FUNCTIONS OF THE OUTPUT, SEE SEC. 3.4 FOR DESCRIPTION.

Start-address for program: 1

Program-memory locations used: 1-35

Parameters stored: (fixed)

Register name	Register address	Parameter
STATUS-REG.	1,	004020 (SELECT TEST DATA INPUT)
SAR	4,	1
LOOP-COUNTER	22,	777, PARAMETER FOR SCANNING THE TEST DATA MEMORY
APB-STACK 1	20,1,	INCREMENT FOR ADDRESS ACCUMULATION
APB-STACK 17	20,17,	154, LOCATION IN TEST DATA MEMORY FOR GENERATING x=1

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: H5: TESTS ON 32-BITS ACCUMULATORS **File-name (NORD-10):** (CORR)H5: DATA

Program version:

Functional description:

- SUBROUTINE 1: TEST OF FUNCTION $\sum (-1)^n$
- SUBROUTINE 2: TEST OF LOADING THE ACCUMULATORS
- SUBROUTINE 3: TEST OF $\sum_w x^2 + y^2$
- SUBROUTINE 4: TEST OF $\sum_n x+y$

Start-address for program: SUB 1:1, SUB2:16, SUB3:21, SUB4:27

Program-memory locations used: SUB1:1-7
 SUB2:16-20
 SUB3:21-26
 SUB4:27-34

Parameters stored:

Register name	Register address	Parameter
STATUS REG. SAR	1, 4,	004020 1,16,21 OR 27 (OPTIONAL)
SUB1: LOOP-COUNTER 1 - " - 2 - " - 3	22, 23, 24,	7777) 4000) CONTROLLING 1000) LOOPING
SUB2: LOOP-COUNTER 1 APB-STACK 14 - " - 13	22, 20,14, 20,13,	777 0: STARTADDR. IN TEST-M. 1: INCREMENT
SUB 3 AND 4: LOOP-COUNTER 1 LOOP-COUNTER 2 APB-STACK 14 - " - 13 - " - 12	22, 23, 20,14 20,13 20,12	NO OF VALUES-2 FOR ACCUMULATION NO OF ACCUMULATIONS-1. STARTADDRESS IN TEST-M INCREMENT START PRINT FOR NEW ACCUMULATION RELATIVE TO LAST VALUE IN PRECEDING ACCUMULATION

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: H6: TESTS ON RESULT-MEMORY TIMING **File-name (NORD-10):** (CORR)H6: DATA

Program version:

Functional description:

Program with no end, and is used for generating oscilloscope-display. The program repeats execution on location $0_8, 1777_8$ and 1000_8 in result-memory. The test-function is accumulation with +1,-1.

Start-address for program: 1

Program-memory locations used: 1-6

Parameters stored: (fixed setup)

Register name	Register address	Parameter
STATUS-REG.	1,	004020,
SAR-REGISTER	4,	1,
LCR1	22,	10,
LCR3	24,	0,
APB-STACK 0	20,0,	160,) USED AS
APB-STACK 1	20,1	221,) ADDRESS POINTERS
APB-STACK 2	20,2,	154,) FOR VALUE H AND
APM-STACK 0	21,0,	0) -1 IN PROM
APM-STACK 1	21,1,	1777) LOCATIONS TO
APM-STACK 2	21,2,	1000) BE TESTED

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: S1:TEST ON PROGRAM
EXECUTION

File-name (NORD-10): (CORR)S1: DATA

Program version:

Same as μ -program H1 but with DMA-transfer of program-counter from correlator to computer.

Functional description:

See description of H1.

Start-address for program: 1

Program-memory locations used: 1-67

Parameters stored: (fixed setup)

Register name	Register address	Parameter
	Same as program H1	

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker
Date: August 1978

Program name: S2: TEST ON LOADING THE RESULT-MEMORY
File-name (NORD-10): (CORR) S2: DATA
Program version: I

Functional description:

See text

Start-address for program : 1: TEST ON LOADING -1 TO RESULT-MEMORY
2: TEST ON LOADING 0 TO RESULT-MEMORY
Program-memory locations used: 3: TEST ON LOADING THE TEST-SEQUENCE TO THE RESULT-MEMORY
1-55

Parameters stored:

Register name	Register address	Parameter
	See Ch. 4.2	

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: S3: POWER PROFILE

File-name (NORD-10): (CORR)S3:DATA

Program version: III

Functional description:

$$\text{DATA-CHANNEL 1: } K_r = \sum_{i=0}^{N-1} x_i^2 + y_i^2, \quad r = 0, 1, \dots, R$$

$$\text{DATA-CHANNEL 2: } L_r = \sum_{i=0}^{N-1} x_i + y_i, \quad r = 0, 1, \dots, R$$

Start-address for program: 1

Program-memory locations used: 1-15, 40-53

Parameters stored:

Register name	Register address	Parameter
STATUS-WORD	1,	004020
SAR	4,	1
LCR1	22,	NO OF SAMPLES -2 IN RANGE-GATE
LCR2	23,	NO OF RANGE GATES -1
LCR3	24,	NO OF 64-BITS WORDS FOR DMA-TRANSFER
APB-STACK REG. 12	20, 12,	RANGE GATE INCREMENT ON INPUT
" -	20, 13,	SAMPLE INCREMENT ON INPUT
" -	20, 14,	START-ADDRESS ON INPUT
APM-STACK REG. 13	21, 13,	INCREMENT IN RESULT-MEMORY
" -	21, 14,	START-ADDRESS IN RESULT-MEMORY

Flag operation: NOOP

MICRO-PROGRAM FOR DIGITAL CORRELATOR

Author: H.J. Alker

Date: August 1978

Program name: S4: AUTOCORRELATION

File-name (NORD-10): (CORR)S4:DATA

Program version: I

Functional description:

ALGORITHM: $R_{\ell,r} = \sum_{i=0}^{N-1-\ell} (x_i x_{i+\ell} + y_i y_{i+\ell})$ $\ell = 0, 1, \dots, N-1$

$I_{\ell,r} = \sum_{i=0}^{N-1-\ell} (x_i y_{i+\ell} - x_{i+\ell} y_i)$ $\ell = \text{lag index}$
 $r = \text{range-gate index}$

Start-address for program: 7

Program-memory locations used: 7-25, 40-53,

Parameters stored:

Register name	Register address	Parameter
STATUS WORD	1,	004020
SAR	4,	7
LCR1	22,	NO OF LAGS -1 (ℓ)
LCR2	23,	NO OF RANGE-GATES -1 (r)
LCR3	24,	DMA
APB-STACK REG 15	20, 15,	RANGE-GATE INCREMENT AT INPUT
- " - 16	20, 16,	SAMPLE INCREMENT
- " - 17	20, 17,	STARTADDRESS AT INPUT
APM-STACK REG.13	21, 13,	SAMPLE INCREMENT FOR DMA
- " - 14	21, 14,	STARTADDRESS FOR DMA
- " - 15	21, 15,	MUST BE $>$ LCR1+1, RANGE-GATE INCR. FOR RES. MEMORY
- " - 16	21, 16,	DATA INCREMENT IN RES. MEM.
- " - 17	21, 17,	START-ADDRESS IN RES. MEM.

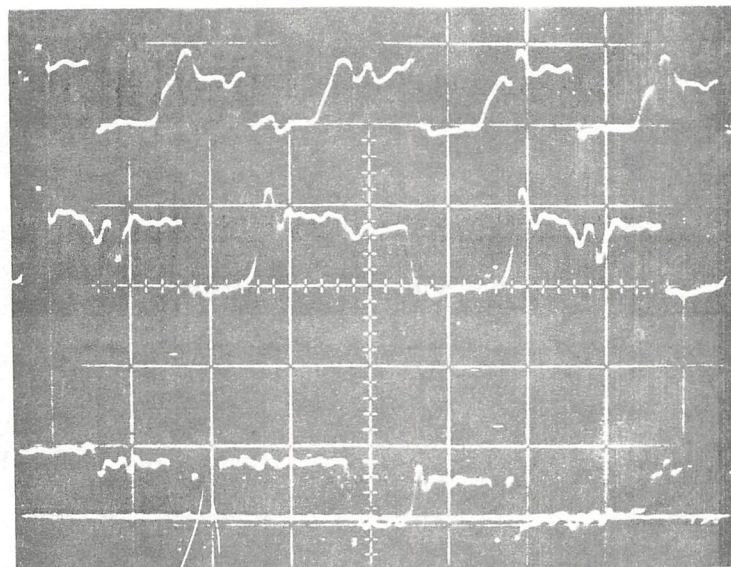
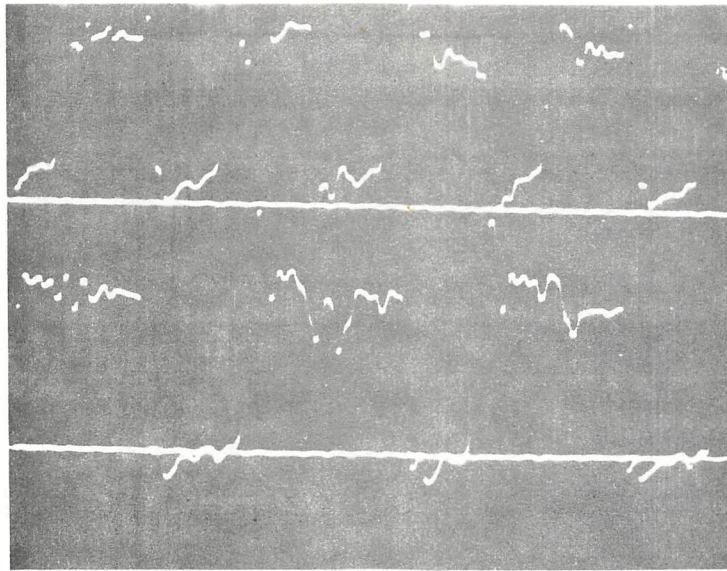
Flag operation: NOOP

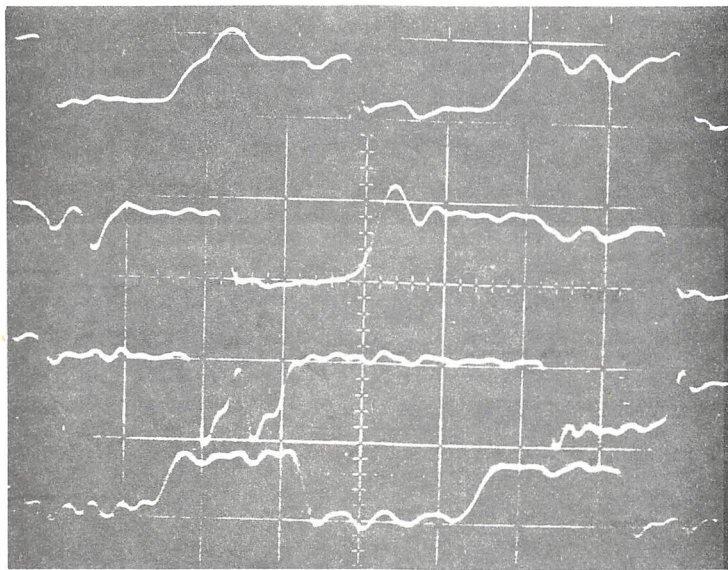
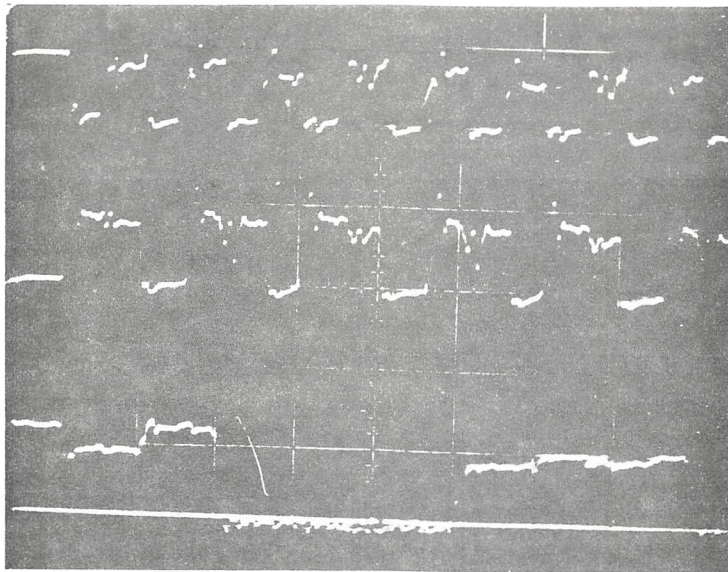
REGISTERS IN DATAFIELD DEFINED

STATUS-REGISTER = 004020
START-ADDR. REGISTER = 01
REGISTER FOR LOOP-COUNTER 1 = 0010

APB-STACK :
REG.00=000160
REG.01=000221
REG.02=000154

APM-STACK ;
REG.00=0000
REG.10=1777
REG.11=7777





DIRECT SIMULATION OF CORRELATOR ARITHMETIC

START ON PROGRAM FOR AUTOCORRELATION (ALL LAGS COMPUTED)

PARAMETERS DEFINED : NO. OF SAMPLES IN RANGE GATE : 0021
 NO. OF RANGE GATES : 0075
 START ADDRESS IN BUFFER : 000000
 SAMPLE-INCREMENT : 000001
 RANGE GATE-INCREMENT : 000012
 START ADDRESS IN RESULT-MEMORY : 0000
 LAG-INCREMENT : 0001
 RANGE GATE-INCREMENT : 0021

DISPLAY OF DATA AFTER 001777 STARTS

LOWER, UPPER LIMIT IN RESULT-MEMORY : 000000, 001777

RES. MEM. LOCATION DATA1(MS) DATA1(LS) DATA2(MS) DATA2(LS)

0000	002670	110600	000000	000000
0001	000122	113525	177542	157522
0002	177323	103461	177705	007300
0003	177654	144323	000037	177776
0004	000064	113327	177704	121333
0005	000117	004071	177566	025176
0006	000041	135617	000165	017261
0007	177746	053154	177513	024501
0010	177341	115653	177363	177421
0011	177423	031502	177545	167216
0012	000025	007273	000440	163664
0013	000220	157677	000113	074435
0014	177753	134423	177640	033770
0015	177745	161211	000011	044655
0016	177711	160613	000247	160775
0017	177716	110137	000144	041351
0020	177740	117732	000046	177076
0021	002407	162666	000000	000000
0022	177752	142520	177660	031770
0023	176755	040321	177504	161323
0024	000001	143616	000535	014244
0025	000463	133377	000352	160471
0026	177545	047266	177216	020217
0027	177646	121135	177467	177015
0030	177736	062151	000452	044533
0031	177767	155012	000204	123316
0032	177740	047756	177677	044062

0033	177607	171013	000045	127222
0034	177617	136030	000021	107633
0035	177770	026765	177706	025171
0036	000141	063640	177703	117434
0037	000023	117427	000001	013672
0040	000040	001775	177760	013773
0041	000013	032462	000020	157707
0042	001706	101043	000000	000000
0043	000215	124215	000061	117625
0044	177542	017602	000175	160200
0045	177500	053766	000427	117007
0046	177662	121534	177766	045156
0047	000140	123720	177515	142232
0050	000067	031060	177624	025374
0051	177631	024674	177570	126735
0052	000245	177166	000052	040555
0053	000222	033551	000141	077632
0054	000212	152502	177744	033364
0055	177505	003312	000022	007573
0056	177363	057471	000036	046153
0057	177740	111735	177706	013176
0060	000131	156603	177506	061163
0061	000050	166702	177652	070551
0062	000047	055047	177721	063651
0063	002000	103636	000000	000000
0064	000406	107114	000152	076532
0065	177716	014175	177710	142722
0066	177463	165422	177570	142727
0067	177556	054163	177402	045575
0070	177771	002677	177437	034100
0071	177567	141030	000111	116624
0072	177544	165317	177614	022376
0073	000004	177300	177737	070046
0074	000302	133506	177747	175003
0075	000172	136511	000226	107123
0076	177606	007204	000172	152503
0077	177463	157425	000115	070237
0100	177761	117631	177774	150314
0101	000112	146510	177570	022777
0102	000106	071137	177725	145220
0103	000023	005474	000030	040756
0104	001545	167116	000000	000000
0105	000024	113331	000010	102736
0106	000242	101525	000041	121625

0107	177710	116734	000157	036052
0110	177702	175505	177772	112533
0111	177731	116633	000044	007372
0112	000235	156177	177761	015672
0113	177547	003110	177723	177403
0114	000017	030063	177732	174504
0115	000021	073641	000142	111525
0116	000176	012163	177543	121441
0117	000132	154504	000172	174472
0120	000164	057341	177772	144516
0121	177666	057155	000163	031454
0122	177746	171105	000167	055042
0123	177663	035466	000122	031556
0124	177727	005100	000001	003676
0125	002165	121120	000000	000000
0126	177262	157535	177223	107463
0127	000063	161404	000203	121417
0130	000315	074225	177557	044067
0131	177353	122450	177667	111040
0132	000217	070033	000054	040355
0133	177553	022500	177513	062462
0134	177757	146016	000241	001665
0135	000077	120024	177621	103645
0136	177512	060563	177746	013174
0137	000077	162003	000166	127115
0140	177651	052660	177537	074054
0141	177730	172705	000212	146504
0142	177667	071050	177737	134024
0143	000162	173473	000120	067737
0144	000033	064444	000014	052352
0145	000050	046752	177710	022772
0146	003477	155625	000000	000000
0147	000311	122612	177461	025702
0150	177551	070655	000152	102530
0151	177532	172515	000313	022452
0152	177405	175221	000005	177200
0153	000007	167004	177653	060455
0154	000403	105415	177761	153613
0155	177621	021676	177053	000535
0156	177372	014612	177507	045071
0157	177743	177402	000307	065031
0160	000070	136715	000161	131614
0161	000116	114125	000001	155611
0162	000115	162202	177600	053762

0163	000043	067442	177510	017004
0164	177413	150433	177700	004002
0165	000201	137610	000323	135404
0166	177760	031764	177641	057656
0167	001274	136245	000000	000000
0170	177732	154514	000106	067140
0171	000123	063441	000147	176772
0172	000103	165401	000061	177575
0173	177731	030666	177726	173105
0174	000003	155411	177762	043557
0175	177704	133326	177666	051160
0176	000056	104133	177741	161611
0177	000110	100733	177653	076446
0200	000040	161705	000132	034554
0201	177751	144617	177712	020573
0202	000137	016063	000134	116323
0203	000005	145215	000040	055747
0204	177743	155413	000032	002575
0205	177750	170705	000136	060142
0206	000002	025565	177761	115632
0207	177743	155413	177723	041462
0210	003603	005305	000000	000000
0211	001001	115571	000651	036626
0212	177064	127361	000041	111631
0213	000153	064437	177406	101157
0214	001075	102173	000174	132313
0215	000320	035744	000264	071330
0216	177506	111147	177352	122550
0217	000222	115520	177623	113441
0220	000601	043626	000336	154074
0221	000576	010144	000374	172263
0222	000152	162500	000322	031546
0223	000100	015765	000162	005566
0224	000003	011473	000005	037260
0225	000103	155405	177647	005103
0226	000155	026256	177747	147016
0227	177757	104037	000007	065045
0230	177777	004076	177757	140021
0231	002702	107400	000000	000000
0232	000544	133274	177726	125130
0233	000176	050144	000443	131401
0234	000757	137761	000050	032760
0235	000002	127524	177517	142032
0236	177776	114132	000373	152373

0237	000601	031633	177712	156514
0240	000352	026546	177473	032477
0241	177777	172003	000310	130707
0242	000316	012156	000250	030751
0243	177711	064651	000145	111225
0244	177572	024576	000260	145702
0245	000123	051446	177744	033364
0246	177757	124027	177567	005106
0247	000055	066242	177726	071146
0250	177777	160010	177677	104042
0251	177772	030564	177774	022367
0252	001713	132326	000000	000000
0253	177770	164706	177576	042167
0254	177732	062551	000262	041544
0255	000142	037552	177630	134730
0256	177511	170617	177660	145722
0257	177620	004005	000353	164367
0260	000161	165576	177410	120747
0261	177610	160717	177734	166307
0262	000270	010760	000225	005264
0263	000152	162500	177650	007002
0264	177651	024673	000017	144015
0265	000121	055644	000243	013460
0266	177725	127227	000107	115025
0267	000055	006272	000027	115030
0270	000241	027652	177770	012773
0271	000053	046452	177774	026365
0272	177762	145516	000005	125225
0273	003474	146131	000000	000000
0274	000064	143313	000043	111431
0275	001253	106362	000316	104121
0276	177171	100670	000217	156000
0277	000546	023140	000242	037546
0300	177146	025217	000201	121617
0301	000263	165372	000604	045325
0302	177511	154625	000257	072030
0303	000634	146263	000240	101725
0304	177502	127540	000025	143215
0305	000303	001463	000130	074734
0306	177505	113246	000131	162601
0307	000011	124625	000146	033154
0310	177476	006211	000227	065034
0311	177754	010375	000046	065143
0312	000031	116627	000111	154605

0313	000127	101032	177710	130727
0314	003023	033321	000000	000000
0315	000406	041137	000363	107415
0316	177342	143540	000225	027253
0317	177252	110561	000061	115626
0320	000225	015260	177562	173513
0321	001007	164745	000260	141704
0322	000055	154207	177674	000404
0323	177523	001512	177612	134531
0324	177462	105552	177614	154321
0325	000322	033545	177550	024777
0326	000343	007456	000205	165175
0327	000321	155574	177767	047055
0330	177767	155012	177772	154512
0331	177460	173717	177653	046462
0332	000236	162075	177761	005676
0333	177726	063151	000007	147014
0334	000041	051651	000014	000377
0335	002462	057425	000000	000000
0336	000545	137172	177601	077650
0337	000402	101517	177647	107042
0340	177501	123642	000032	102535
0341	177335	026307	000435	006253
0342	177372	014612	000516	044131
0343	177627	105044	000225	061236
0344	177642	171511	000112	036554
0345	177723	115434	177514	052366
0346	000115	020263	177466	177115
0347	000035	116227	177467	037075
0350	000125	177173	177623	071452
0351	177705	007300	177453	052470
0352	000020	013771	177723	151416
0353	177773	050454	177722	015574
0354	177726	157113	000005	133222
0355	000010	124725	177772	146515
0356	002372	166365	000000	000000
0357	000001	167604	177477	060064
0360	177713	174405	177677	052057
0361	177703	153416	000051	144613
0362	000262	175466	000253	152400
0363	000003	067444	177622	163515
0364	177710	003002	000062	051550
0365	000042	027562	177654	074347
0366	177764	033363	000011	130623

0367	177570	160720	177766	161110
0370	000145	017262	000302	177464
0371	177712	112536	177576	114142
0372	177711	040663	177732	012575
0373	177773	060450	177511	102652
0374	177722	057553	177743	141421
0375	177562	063557	177613	152422
0376	177545	167216	177640	065753
0377	002267	010760	000000	000000
0400	000357	050035	000341	037642
0401	177741	117632	000336	144100
0402	177660	113737	177653	034467
0403	177260	004023	177602	051563
0404	177724	131326	177607	167014
0405	177616	022176	177541	077652
0406	177745	065247	177775	116231
0407	000160	121720	177750	114733
0410	177620	047763	000233	030452
0411	177405	125245	000015	170203
0412	177724	053355	177617	172012
0413	177774	112333	000032	160506
0414	000167	155002	000072	000574
0415	000037	010072	000165	171174
0416	177725	151216	177737	024070
0417	000024	111332	177744	167306
0420	002330	030646	000000	000000
0421	000053	142414	000633	144364
0422	177642	163514	177556	076152
0423	177734	054354	177674	074346
0424	000207	067034	177455	154227
0425	000255	100225	000316	156074
0426	177575	136231	177722	133525
0427	000056	050151	000252	150501
0430	177730	024770	000006	125125
0431	000146	015163	000122	175474
0432	177621	031672	177733	042461
0433	000416	064125	177374	060370
0434	000260	171670	000263	047441
0435	177643	035467	000103	027460
0436	000034	106333	177722	165510
0437	000135	156203	177645	011301
0440	000146	031155	177726	073145
0441	002265	065132	000000	000000
0442	177643	067452	000747	146756

0443	000211	152602	000232	012561
0444	177013	060507	000501	155565
0445	177755	140221	177137	156043
0446	177773	020470	177667	163013
0447	000434	050332	177223	035510
0450	000330	000762	000267	151000
0451	000313	160373	000004	007374
0452	000037	020066	000526	127077
0453	177342	055573	177563	123437
0454	000123	055444	177673	100444
0455	177676	042163	177653	004503
0456	000265	107221	177704	103342
0457	000027	021066	000105	101233
0460	000012	016570	177732	054554
0461	000023	045454	000002	157510
0462	002401	147474	000000	000000
0463	000031	066643	177470	144732
0464	000234	060336	177721	077643
0465	000152	154503	177257	072070
0466	177550	026776	177603	051463
0467	177530	152725	177764	023367
0470	177470	114746	177302	161533
0471	177743	007476	000342	061531
0472	000115	152206	177657	112040
0473	177721	027667	177646	151121
0474	000200	111723	000127	021062
0475	000357	134003	177574	130334
0476	177547	111045	000005	067244
0477	000045	077236	177675	064252
0500	177531	030676	177712	032566
0501	000012	064545	000011	070643
0502	177727	033065	177764	121330
0503	002773	004336	000000	000000
0504	000202	045545	000027	167003
0505	000072	062543	000133	134414
0506	177170	126755	000274	060334
0507	177022	027623	177670	106741
0510	177733	132425	177405	123246
0511	000325	135204	000001	027664
0512	000515	162162	177304	117354
0513	000265	101224	000312	134505
0514	177437	144034	000244	163274
0515	177613	056460	000214	116320
0516	177522	045570	177766	075142

0517	177662	175506	177506	173116
0520	000066	117125	177554	100351
0521	000214	160277	177711	120633
0522	000133	120422	177731	114634
0523	000031	014670	000122	035554
0524	003161	053503	000000	000000
0525	177212	144545	177707	107040
0526	000146	061141	177155	170235
0527	177440	057766	000354	076322
0530	000210	134711	177576	170114
0531	177647	043064	000170	122717
0532	177660	021774	177235	054300
0533	000157	160001	000067	073037
0534	177562	117541	177631	130632
0535	000126	035154	000151	026656
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1447	000252	040545	000227	025054
1450	000174	124316	177701	167610
1451	000337	177762	177454	040375
1452	177576	124136	177674	164312
1453	177100	163742	177635	006303
1454	177252	050601	000066	175076
1455	177630	176707	000202	003566
1456	000156	126116	177767	113033
1457	177771	006675	177667	065052
1460	001746	001101	000000	000000
1461	000643	111401	000010	042756
1462	000520	053725	000026	117127

1463	000340	143700	000104	055345
1464	000036	074140	177756	142120
1465	177653	110441	177631	060656
1466	177721	047657	177716	166110
1467	177771	054652	177667	013077
1470	000045	161205	177460	004013
1471	000213	142406	177664	137325
1472	000145	025257	177470	152727
1473	000064	173277	177417	064065
1474	177752	120531	177462	145532
1475	000024	017367	177607	015101
1476	177762	065546	177544	067356
1477	177743	101441	177660	105742
1500	177644	135327	177765	145216
1501	001602	105445	000000	000000
1502	177524	131336	000037	034060
1503	000255	042244	000247	017056
1504	000177	132013	177635	144224
1505	177712	124531	000251	120615
1506	000456	072120	177572	162517
1507	177743	103440	000136	134114
1510	000243	001465	000240	131711
1511	000040	073740	177625	015300
1512	000053	026462	000152	046546
1513	000247	077026	177624	063355
1514	177725	063251	000224	071332
1515	000315	120213	000046	171101
1516	177674	026371	000043	041455
1517	000017	152012	000105	175175
1520	000025	001276	000032	122525
1521	000005	121227	000000	161707
1522	002536	006047	000000	000000
1523	000545	053224	000241	167572
1524	000264	067331	000010	050753
1525	177547	137032	177712	036564
1526	176776	032223	000131	114624
1527	177145	175233	177703	141423
1530	177420	175720	177740	057752
1531	177512	064561	000177	116021
1532	177772	126525	177577	064056
1533	000276	010160	000040	151711
1534	000164	037351	177665	017275
1535	000241	123614	000054	030361
1536	000047	055047	000165	117221

1537	177667	065052	000037	006073
1540	000011	072642	177745	167206
1541	000024	135320	000014	164305
1542	177772	066545	000002	037560
1543	002447	112710	000000	000000
1544	177713	016474	000014	130323
1545	177672	002603	000122	023561
1546	177725	171206	177545	133234
1547	177373	170424	000010	042756
1550	177474	064362	177512	120543
1551	000326	057133	177437	146033
1552	000310	110717	177714	156314
1553	000326	117113	177644	027372
1554	177410	015011	000120	067737
1555	000060	025762	000031	126623
1556	177362	073563	177576	170114
1557	177620	113741	000204	173272
1560	000134	064340	177647	141025
1561	000065	155206	177674	162313
1562	177702	001603	000077	146011
1563	000000	051753	000041	103634
1564	002707	110677	000000	000000
1565	000322	005560	000200	061737
1566	000313	100423	000026	111132
1567	000262	005562	177575	004306
1570	000440	113710	177753	074443
1571	001042	065503	000073	016465
1572	177576	050164	000060	165702
1573	000544	047326	177724	041362
1574	000431	104614	177677	122033
1575	000304	027350	000254	064333
1576	000302	077524	000235	144204
1577	177610	015001	177720	007777
1600	000312	116514	177530	015004
1601	000054	174277	177753	044457
1602	000145	173174	177770	001000
1603	000123	171376	177746	017172
1604	000023	051452	177767	071044
1605	002743	047316	000000	000000
1606	177123	013525	177163	143447
1607	000204	137310	000514	176254
1610	000245	047242	177464	005412
1611	177171	062677	177452	054567
1612	177564	115342	000614	002346

1613	177670	003003	177567	027075
1614	177656	172110	000345	111215
1615	000062	051550	177634	154320
1616	177707	073046	000114	152306
1617	000207	170773	177776	156111
1620	177600	057760	177522	111546
1621	000072	046551	000106	173076
1622	000126	153105	177770	060750
1623	000007	165005	000023	137417
1624	177741	057652	000014	174301
1625	177762	123527	177763	033463
1626	002567	130674	000000	000000
1627	177763	035462	000253	134407
1630	177436	132141	177764	153313
1631	000354	166266	177650	076746
1632	177722	145520	000117	060043
1633	177174	136351	000154	110325
1634	000276	056135	000101	013666
1635	177511	056664	000063	103433
1636	177621	111642	177630	150722
1637	000164	121320	000133	140412
1640	177731	156613	000216	066134
1641	177635	176207	177672	024572
1642	000335	072225	177515	020303
1643	000035	066243	177733	114434
1644	000151	054643	000011	000677
1645	000015	104235	177764	131324
1646	177730	060752	000123	033455
1647	002455	136076	000000	000000
1650	000404	005355	000747	025027
1651	177605	111243	000131	016663
1652	177637	042065	177711	156614
1653	000154	070335	000135	110226
1654	000011	116630	000177	100030
1655	177572	152523	177700	041763
1656	000027	055050	177472	000614
1657	000100	165701	000014	020367
1660	177547	175013	000127	117023
1661	177324	011416	177745	077242
1662	177711	112636	177433	142435
1663	177764	005376	177524	105350
1664	000266	005162	177513	022502
1665	000023	177377	177733	070446
1666	000110	170677	177774	006375

1667	177775	106235	000016	124125
1670	001247	142744	000000	000000
1671	177607	121037	000267	145002
1672	000057	010071	177763	141420
1673	177647	105043	000141	137612
1674	000207	135011	177776	136121
1675	000000	055751	000117	160003
1676	177731	006677	177770	120730
1677	177756	174103	000266	165072
1700	177634	036367	177727	131026
1701	177747	103040	000027	063045
1702	177744	045357	177717	012076
1703	000005	005275	000102	155505
1704	177644	033370	177757	052054
1705	000012	022566	177705	173206
1706	177740	051755	000065	111230
1707	000011	010673	177613	012502
1710	000122	053545	177764	077341
1711	002602	047424	000000	000000
1712	000440	115707	000034	160306
1713	000205	125215	000244	145303
1714	000217	046044	177610	116740
1715	177575	110244	177232	042605
1716	177437	144034	177665	177205
1717	177465	153227	177657	006102
1720	177500	035775	177351	170625
1721	177562	111544	177630	052761
1722	000110	002772	177570	036771
1723	177707	147020	000127	043051
1724	177742	147516	000166	023157
1725	177673	100444	000073	052447
1726	177637	144024	000335	016253
1727	177706	077144	000102	157504
1730	177747	037062	000111	152606
1731	177760	133723	000053	072440
1732	002202	071433	000000	000000
1733	177453	156426	177354	116352
1734	000054	130321	000227	063035
1735	177642	051561	000072	152507
1736	177373	146435	000175	000270
1737	000127	041052	000026	161106
1740	177572	000610	000021	015670
1741	177761	007675	000015	154211
1742	000444	075317	177771	044656

1743	177457	044073	177403	113452
1744	000051	066642	000455	020245
1745	177227	055054	000014	166304
1746	177712	064551	000127	075034
1747	000135	030256	177744	165307
1750	177661	113637	177627	031072
1751	000031	134620	177756	016172
1752	177745	033264	177753	100441
1753	002723	071306	000000	000000
1754	000052	132520	177547	115043
1755	177277	004122	000066	063143
1756	177555	024277	000276	104122
1757	177703	025471	177517	000113
1760	000251	074627	177531	130636
1761	177756	172104	000327	031046
1762	000045	125223	000014	052352
1763	177255	146242	177664	115336
1764	177453	004513	177372	062567
1765	000232	074530	000204	065335
1766	000342	145477	000072	106531
1767	000132	140512	177455	034277
1770	177437	066063	000171	076631
1771	177650	166712	000055	076236
1772	000112	002572	177742	153514
1773	177772	110534	177726	101142
1774	003044	071201	000000	000000
1775	000061	021664	177453	052470
1776	176622	127573	177755	024267
1777	000005	135221	001022	133461

* * * A LISTING OF A DATA-DUMP FROM A TEST-PROGRAM IN THE CORRELATOR * * * *

THIS LISTING WAS PRODUCED BY THE CORRELATOR-SIMULATION PROGRAM
(THE DATA WAS TRANSFERRED FROM THE CORRELATOR TO THE COMPUTER MEMORY VIA DMA)

SYSTEM-TEST S4:AUTOCORRELATION WITH ACCUMULATION(1777)

0000: 002670 110600 000000 000000
 0003: 177654 144323 000037 177776
 0006: 000041 135617 000165 017261
 0011: 177423 031502 177545 167216
 0014: 177753 134423 177640 033770
 0017: 177716 110137 000144 041351
 0022: 177752 142520 177660 031770
 0025: 000463 133377 000352 160471
 0030: 177736 062151 000452 044533
 0033: 177607 171013 000045 127222
 0036: 000141 063640 177703 117434
 0041: 000013 032462 000020 157707
 0044: 177542 017602 000175 160200
 0047: 000140 123720 177515 142232
 0052: 000245 177166 000052 040555
 0055: 177505 003312 000022 007573
 0060: 000131 156603 177506 061163
 0063: 002000 103636 000000 000000
 0066: 177463 165422 177570 142727
 0071: 177567 141030 000111 116624
 0074: 000302 133506 177747 175003
 0077: 177463 157425 000115 070237
 0102: 000106 071137 177725 145220
 0105: 000024 113331 000010 102736
 0110: 177702 175505 177772 112533
 0113: 177547 003110 177723 177403
 0116: 000176 012163 177543 121441
 0121: 177666 057155 000163 031454
 0124: 177727 005100 000001 003676
 0127: 000063 161404 000203 121417
 0132: 000217 070033 000054 040355
 0135: 000077 120024 177621 103645
 0140: 177651 052660 177537 074054
 0143: 000162 173473 000120 067737
 0146: 003477 155625 000000 000000
 0151: 177532 172515 000313 022452
 0154: 000403 105415 177761 153613
 0157: 177743 177402 000307 065031
 0162: 000115 162202 177600 053762
 0165: 000201 137610 000323 135404
 0170: 177732 154514 000106 067140
 0173: 177731 030666 177726 173105

0001: 000122 113525 177542 157522
 0004: 000064 113327 177704 121333
 0007: 177746 053154 177513 024501
 0012: 000025 007273 000440 163664
 0015: 177745 161211 000011 044655
 0020: 177740 117732 000046 177076
 0023: 176755 040321 177504 161323
 0026: 177545 047266 177216 020217
 0031: 177767 155012 000204 123316
 0034: 177617 136030 000021 107633
 0037: 000023 117427 000001 013672
 0042: 001706 101043 000000 000000
 0045: 177500 053766 000427 117007
 0050: 000067 031060 177624 025374
 0053: 000222 033551 000141 077632
 0056: 177363 057471 000036 046153
 0061: 000050 166702 177652 070551
 0064: 000406 107114 000152 076532
 0067: 177556 054163 177402 045575
 0072: 177544 165317 177614 022376
 0075: 000172 136511 000226 107123
 0100: 177761 117631 177774 150314
 0103: 000023 005474 000030 040756
 0106: 000242 101525 000041 121625
 0111: 177731 116633 000044 007372
 0114: 000017 030063 177732 174504
 0117: 000132 154504 000172 174472
 0122: 177746 171105 000167 055042
 0125: 002165 121120 000000 000000
 0130: 000315 074225 177557 044067
 0133: 177553 022500 177513 062462
 0136: 177512 060563 177746 013174
 0141: 177730 172705 000212 146504
 0144: 000033 064444 000014 052352
 0147: 000311 122612 177461 025702
 0152: 177405 175221 000005 177200
 0155: 177621 021676 177053 000535
 0160: 000070 136715 000161 131614
 0163: 000043 067442 177510 017004
 0166: 177760 031764 177641 057656
 0171: 000123 063441 000147 176772
 0174: 000003 155411 177762 043557

0002: 177323 103461 1777-5 - 7
 0005: 000117 004071 177566
 0010: 177341 115653 177367
 0013: 000220 157677 000113
 0016: 177711 160613 000247
 0021: 002407 162666 000000
 0024: 000001 143616 000535
 0027: 177646 121135 177467
 0032: 177740 047756 177677
 0035: 177770 026765 177706
 0040: 000040 001775 177760
 0043: 000215 124215 000061
 0046: 177662 121534 177766
 0051: 177631 024674 177570
 0054: 000212 152502 177746
 0057: 177740 111735 177706
 0062: 000047 055047 177730
 0065: 177716 014175 177710
 0070: 177771 002677 177477
 0073: 000004 177300 177777
 0076: 177606 007204 000172
 0101: 000112 146510 177570
 0104: 001545 167110 000000
 0107: 177710 116734 000157
 0112: 000235 156177 177761
 0115: 000021 073641 000142
 0120: 000164 057341 177772
 0123: 177663 035466 000122
 0126: 177262 157535 177227
 0131: 177353 122450 177647
 0134: 177757 146016 000241
 0137: 000077 162003 000166
 0142: 177667 071050 177737
 0145: 000050 046752 177710
 0150: 177551 070655 000152
 0153: 000007 167004 177653
 0156: 177372 014612 177507
 0161: 000116 114125 000001
 0164: 177413 150433 177700
 0167: 001274 136245 000000
 0172: 000103 165401 000066
 0175: 177704 133326 177666

0176:	000056	104133	177741	161611	0177:	000110	100733	177653	076446	0200:	000040	161705	000132	071551
0201:	177751	144617	177712	020573	0202:	000137	016063	000134	116323	0203:	000005	145215	000040	055577
0204:	177743	155413	000032	002575	0205:	177750	170705	000136	060142	0206:	000002	025565	177761	115477
0207:	177743	155413	177723	041462	0210:	003603	005305	000000	000000	0211:	001001	115571	000651	076447
0212:	177064	127361	000041	111631	0213:	000153	064437	177406	101157	0214:	001075	102173	000174	135777
0215:	000320	035744	000264	071330	0216:	177506	111147	177352	122550	0217:	000222	115520	177673	118777
0220:	000601	043626	000336	154074	0221:	000576	010144	000374	172263	0222:	000152	162500	000322	070577
0223:	000100	015765	000162	005566	0224:	000003	011473	000005	037260	0225:	000103	155405	177647	005607
0226:	000155	026256	177747	147016	0227:	177757	104037	000007	065045	0230:	177777	004076	177757	140007
0231:	002702	107400	000000	000000	0232:	000544	133274	177726	125130	0233:	000176	050144	000443	177777
0234:	000757	137761	000050	032760	0235:	000002	127524	177517	142032	0236:	177776	114132	000373	050077
0237:	000601	031633	177712	156514	0240:	000352	026546	177473	032477	0241:	177777	172003	000310	070077
0242:	000316	012156	000250	030751	0243:	177711	064651	000145	111225	0244:	177572	024576	000260	060077
0245:	000123	051446	177744	033364	0246:	177757	124027	177567	005106	0247:	000055	066242	177726	070077
0250:	177777	160010	177677	104042	0251:	177772	030564	177774	022367	0252:	001713	132326	000000	000077
0253:	177770	164706	177576	042167	0254:	177732	062551	000262	041544	0255:	000142	037552	177630	134777
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0261:	177610	160717	177734	166307	0262:	000270	010760	000225	005264	0263:	000152	162500	177650	007007
0264:	177651	024673	000017	144015	0265:	000121	055644	000243	013460	0266:	177725	127227	000107	115025
0267:	000055	006272	000027	115030	0270:	000241	027652	177770	012773	0271:	000053	046452	177774	076365
0272:	177762	145516	000005	125225	0273:	003474	146131	000000	000000	0274:	000064	143313	000043	111177
0275:	001253	106362	000316	104121	0276:	177171	100670	000217	156000	0277:	000546	023140	000242	077577
0300:	177146	025217	000201	121617	0301:	000263	165372	000604	045325	0302:	177511	154625	000257	072077
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1320:	000377	157770	000240	123714	1321:	177500	024002	177743	135423	1322:	177570	003007	000063	173377
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