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A GENERAL PURPOSE INTERFACE FOR COMPUTER COMPATIBLE TAPE RECORDERS

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Abstract

Digital magnetic tape recorders now a days are being used widely for on-line data acquisition in scientific experiments. There are a variety of recorders available from foreign manufacturers, but the interface between the scientific instruments and digital tape recorders is to be developed by the user. This report describes a general purpose interface designed and developed at the Physical Research Laboratory (PRL), Ahmedabad, for PERTEC Digital Tape Recorders. A programme for computer read-out has been developed for printing the digital tape data in hexadecimal characters. A sample of data output is presented to demonstrate working of the entire system. The interface has been successfully used for generating IBM 360/44 computer compatible tapes for a variety of scientific experiments.

1. Introduction:

In this computer era the advantages of digital data processing can hardly be over-emphasized. Strip chart recorders lost their effective utility, except for monitoring purposes, as the demand for recording of fast time-varying physical parameters started increasing. Moreover, chart reading is cumbersome and leads to subjective errors apart from the fact that computation of these data has again to be done on a computer in most of the cases. Today voluminous data are recorded using an on-line computer-compatible tape recorder (CCT) and are then processed with the help of a computer.

The digital tape recorders presently available in the market offer many more facilities than what are required by the 'average user'. Normally, a large number of control lines are provided to the user for maximum flexibility to suit to his wide-ranging requirements. The 'general purpose interface to CCT' developed at PRL can be effectively used for most of the scientific applications. The user brings his real time or tape recorded (analog) data and quantizes it by an 8-bit A/D converter at a maximum sampling rate of 20 kHz. This A/D converter output is strobed into the interface at the sampling rate and a 'digital tape' is generated

which can be directly sent to a computer centre for further processing. To check the quality of the recorded data a computer program is developed which gives the hexadecimal print-out of the recorded characters. The tape can also be read using the same interface into a microprocessor, a digital printer, a D/A converter or similar other devices having wide ranges of operating speeds.

2. Principle of operation and system description:

The 8-bit data from the A/D converter is fed to the buffered formatter via a write-buffer (Fig.1). In most of the peripheral digital instruments the interface lines are low-true at the interface[1], with the true level of 0 volt and false level of +3 Volts. The write-buffer, therefore, inverts the output of the A/D converter to match with the negative logic of the buffered formatter. The write-buffer outputs are also simultaneously fed to data display electronics. When using the Buffered Magnetic Tape Transport (BMTT) in 'read' mode, the data through a read-buffer is fed to the data display electronics as well as to other equipments like a digital printer, a D/A converter or a microprocessor. The data being displayed are controlledby write/read model selection switch. The BMTT can be operated in two modes

namely (1) split buffer mode and (2) single buffer mode. In the split buffer mode, the total length of the buffer is divided into two equal parts. When one buffer B accepts and stores data from the write-buffer asynchronously, the contents of the second buffer A are transferred to the tape via the formatter synchronously at the maximum transfer rate, depending upon the speed and data density of the tape transport, which in our case is about 20 K bytes/sec. When the buffer B is full, the data input is now switched to the buffer A and the contents of the buffer B are transferred to the tape via the formatter. Thus, the two buffers are switched alternately between the write buffer and the formatter. This ensures continuous data recording without any loss. Whereas in the single buffer mode the input data are lost during the transfer of the buffer contents to the tape via the formatter. This CCT interface offers split buffer mode of operation. It also provides automatic mode of operation in which data from buffer are transferred to the tape via the formatter automatically i.e. without any external commands from the CCT interface.

Numerous control lines[2] are provided to make a BMTT flexible enough to meet the requirements of various applications. From our experience only the following

control lines are sufficient for data acquisition systems for scientific applications. A controller generates the necessary signals for these lines. The controls selected are:

(A) WRT/READ : To select the record or play-back mode.

(B) REV/FWD : For controlling the direction of tape motion.

(C) GO : To initiate the operation of BMTT.

(D) ANS STROBE: To latch the input data into the buffers.

(E) EEN : To inhibit or enable the BMTT operation.

(F) WFM : At the end of data acquisition, this control writes a filemark (13_H) on the tape which is a 'must' for computer read outs.

(G) ERASE : This control helps in erasing a previously written filemark or a number of records and helps in rereading of a record.

Status information during operation is very useful for monitoring and assessing the performance of the BMTT. Various status informations[2] are provided by the

BMTT system but the following are the ones which are most useful. They are described below and are displayed on the CCT interface front panel.

(A) BUFFER A BUSY/BUFFER B BUSY: This signifies that the relevant buffers are functioning.

(B) FORMATTER BUSY: Displays the formatter status after the INITIATE command.

(C) DATA BUSY: This shows that the transport has reached the operating speed after initial start up.

(D) FILE MARK: shows that the formatter has detected a file mark during read operation.

(E) HARD ERROR: This displays that an uncorrectable read error has been detected by the formatter; corresponding to vertical parity error on data character, LRCC and CRCC parity error, or improper record format. This is useful particularly when tapes written on other transports are read.

The LRCC, CRCC, and parity bits are internally generated by the formatter.

Before the start of data acquisition and recording the performance of the CCT interface is checked using the test circuit. This test circuit replaces the A/D converter and provides a known data sequence. Few records are written and then read slowly to ascertain the performance of the system.

3. Control signal generator:

As described earlier, this generates various control signals (Fig.2) for the interface. A/D converter sampling pulses are connected to one of the inputs of a 2-input NAND gate. The second input of NAND gate is from the MANUAL ANS STROBE switch via debouncing circuit. The output of this NAND gate is connected to a monoshot multivibrator which delivers pulses to the ANS STROBE line B13 through an open collector buffered inverter. The MAN ANS STROBES are sometimes useful in READ mode. A WRT/READ switch provides the true/false conditions on the line A4 of the buffered formatter through a buffered inverter. A REV/FWD switch decides direction of tape motion by placing true/false voltages through a buffered inverter on the line B4.

When all the desired controls are selected from front panel switches (e.g. WRITE/READ, FWD/REV, etc.) and

the PERTEC is in a position to receive commands from the controller, a GO pulse is issued from the GO switch to start execution. This pulse is passed through a debouncing circuit, monostable multivibrator and buffered inverter to GO line, B3, of the buffered formatter. Any operation can be terminated by putting false level on A11 with the help of the FEN switch, as it causes the Formatter to revert to the quiescent state.

At the end of a record or a block a file mark is written by placing true level on A5 using the WFM switch and a buffered inverter. A separate GO command is essential for this operation. The ERASE switch can be used to erase a file mark (in conjunction with the WFM switch) or to erase a number of records by making A6 true. Since for most of the applications a split buffer and automatic mode of operations of the BMTT are envisaged here, pins A19 and B9 are permanently connected to true levels via buffered inverters.

4. Status Display:

Status of BMTT system is displayed (Fig.3) on the panel by various LED's. Ready or busy status signals for Buffers A and B, Formatter and Data are available on buffered formatter pin Nos. (of J 104) B25, A25, A23,

and A26 respectively. Since they are coming from open collector IC's of BMTT a terminator resistance network is provided for each of these lines. The signals are then given to LED lamps via a buffered driver. The LED's are connected in a way to match negative logic outputs of BMTT. File Mark and Hard Error status signals are available on pins A30 and A28 (of J 104) respectively. A resistance network is provided before the buffered inverters. Both the pulses are stretched by using mono-shots for operator's easy perception.

5. READ/WRITE data display:

The data can be monitored on the READ/WRITE data display as shown in Fig.4. The 8-bit A/D converter data (bits 0 to7 are connected to the buffered formatter lines WB Ø-WB7 via open collector write buffer inverters, to be compatible with the negative logic of the BMTT system. The outputs of the write buffers are also connected to data Display LED drivers through the gates controlled by a READ/WRITE mode select switch. The LED's also display the data in READ mode. The data lines RD Ø - RD7 and RDp (parity bit), available at socket J 104, are connected to data display LED drivers through the read buffers. They are also controlled by the READ/WRITE mode select switch through gates. As these outputs are

rom open collector IC's, of BMTT, resistance terminations re provided for each of the lines. The read buffer oututs (positive logic) can be connected to any of the rocessing or hard copy equipments. In write mode the dd parity is internally generated by the formatter and ence not displayed on the panel.

. Test Circuit:

A test circuit (Fig.5) generates a sequence of -bit characters using an 8-bit counter which is increented at each ANS STROBE. NE 555 timer IC is used as he basic clock generator. It operates in fast and slow odes selectable by a switch. Fast mode is used for riting the records which can be read conveniently in the low mode. A resistance R1 is a fine control for adjustng the ANS STROBE rate. This is very much helpful while eading the data byte by byte. The output of the clock enerator is connected as ANS STROBES to the interface ontrol and to a pair of 4-bit binary counters (7493) onnected in cascade. This arrangement provides contiuous ANS STROBES in the read mode also. The 4-bit oututs from the first counter are connected to the four ines WB4-WB7 (WB7 as LSB) and the 4-bit outputs of the econd counter are connected to the four lines WB Ø - /B3 (WB Ø as MSB) of the controller write buffer. One

record of 1K characters contains four 'cycles' of this 8-bit counter and hence the starting state of the counter is not crucial. No reset pulse for counters is provided. The test circuit is a plug-in module and can be easily inserted at the input of the CCT interface.

7. System operating procedure:

Following is a typical sequence of operations to prepare an IBM compatible tape on a PERTEC BMTT system using this interface.

1. Switch ON the BMTT. HIDEN and ON indicators light.
2. By pressing the 'write ring' in the slot provided on spool properly load the spool on the transport.
3. Press LOAD switch on the BMTT. The tension arms assume optimum positions to provide enough tension on the tape. If the 'write ring' is properly pressed, the WRT EN indicator lights.
4. Press the LOAD switch once again. The tape starts moving in forward direction and stops at BOT. At this point the LOAD indicator lights.
5. Switch on the power supply for CCT interface and A/D converter. Conform that the analog

voltage is properly fed to A/D converter input. Select a proper sampling rate (upto 20 kHz).

6. Press RESET switch on the BMTT once.

7. Select write and forward tape motion modes by WRT/READ and REV/FWD switches, on the CCT Interface.

8. Activate formatter by FEN switch provided on the interface.

9. Press ON LINE switch on BMTT. This indicator lights.

10. Give GO command. The buffer B goes busy.

11. When the buffer is filled, the first record is written on the tape with an initial gap of about 3.75 inches. The Buffer A goes busy.

12. The data are recorded on a tape in records till the data are over. The IRG is generated internally.

13. Reset the formatter by FEN switch once.

14. Operate WFM switch and issue another GO command. A file mark will be written on the tape. About 3.75 inches of tape will move forward.

15. REWIND the tape and take it out from the BMTT. Now the tape is ready for sending to the computer centre or the tape can be read via the CCT interface by issuing slow ANS STROBES.

8. Computer readout:

The 'Digital tape' prepared from analog data can be read in a computer and a printout of data in hexadecimal characters can be obtained by using a programme shown in Fig.6. Hexadecimal characters can be easily converted into binary bits and the quality of the analog data can be assessed. The computer printout in numerals (0-255) can also be obtained if the FORMAT statement in the main programme is modified. SETBUF is a system subroutine and modifies the 'standard' buffer length when the tape is read into the memory of the computer. The variable JK decides the number of records to be read for the printout. Fig.7 shows a computer printout in hexadecimal characters of the digital tape prepared on the CCT interface by using the test circuit.

9. Conclusion:

This CCT intercace has been successfully used for a variety of scientific experiments. Following are the examples proving the versatility of our CCT INTERFACE

which was successfully used for recording:

1. SOLRAD-11 satellite date from PCM decommutator.

2. The PCM data for the experiment for tracking rocket-released Lithium vapour clonds at Thumba.

3. The AGC recording of the receiving set-up for time standard signals transmitted by the National Physical Laboratory (NPL), New Delhi, for studying the signal strength and fading rate at Ahmedabad.

4. The phase delay data received from OMEGA.transmissions during a balloon flight over New Delhi.

5. Data from convolutional encoder (Viterbi) for polyonomial synthesis.

Acknowledgements:

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assembly and testing of various circuits. Financial support for this work came from Department of Space, Government of India, and is gratefully acknowledged.

References:

1. OEM Users Manual for 'PERTEC' Tape Transports by PERTEC Peripheral Equipments, USA.

2. Operating & Service Manual No.101801 Buffered-NRZI Formatter by PERTEC Peripheral Equipments, USA.

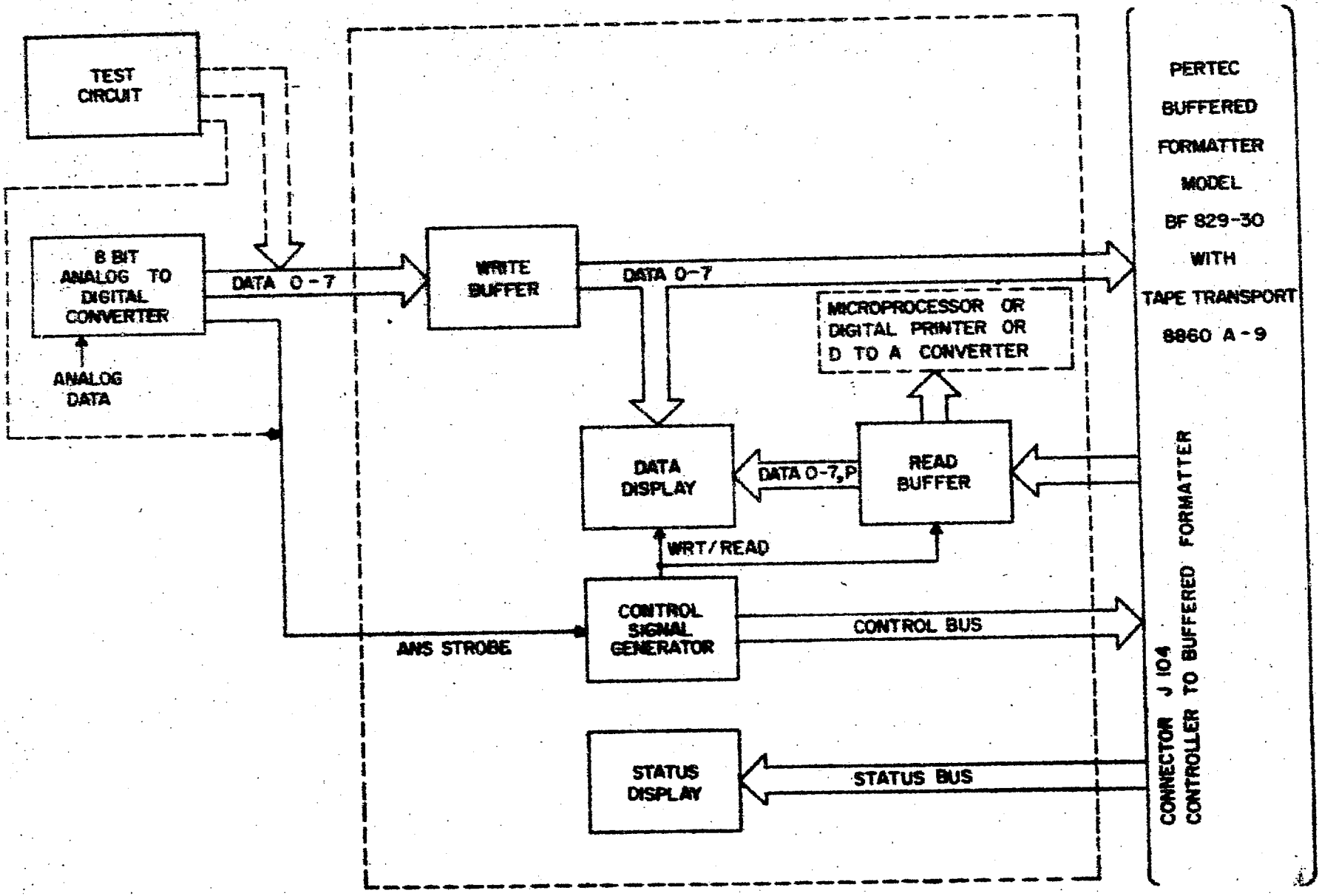

FIG. 1: CCT INTERFACE SCHEMATIC

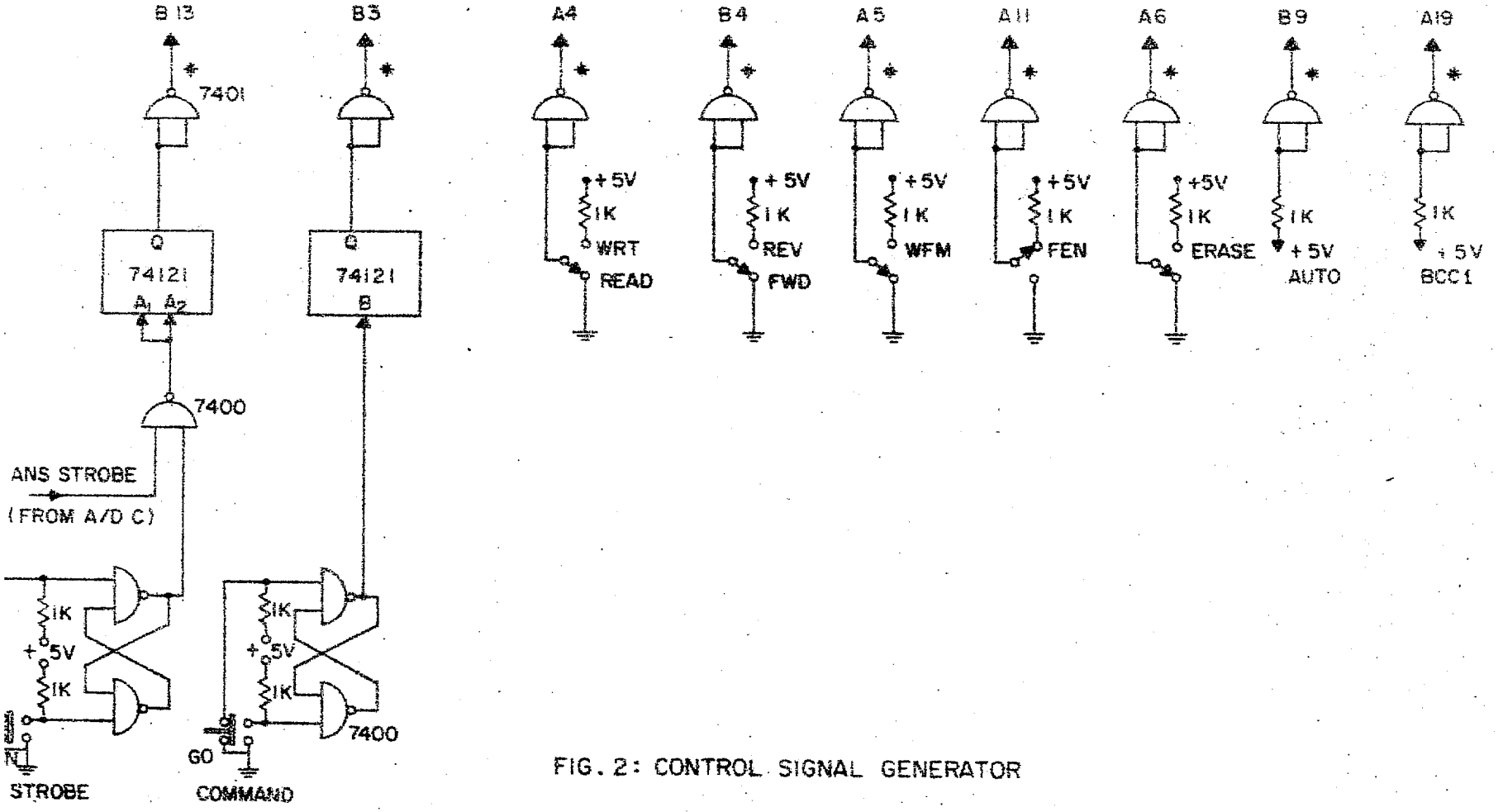

FIG. 2: CONTROL SIGNAL GENERATOR

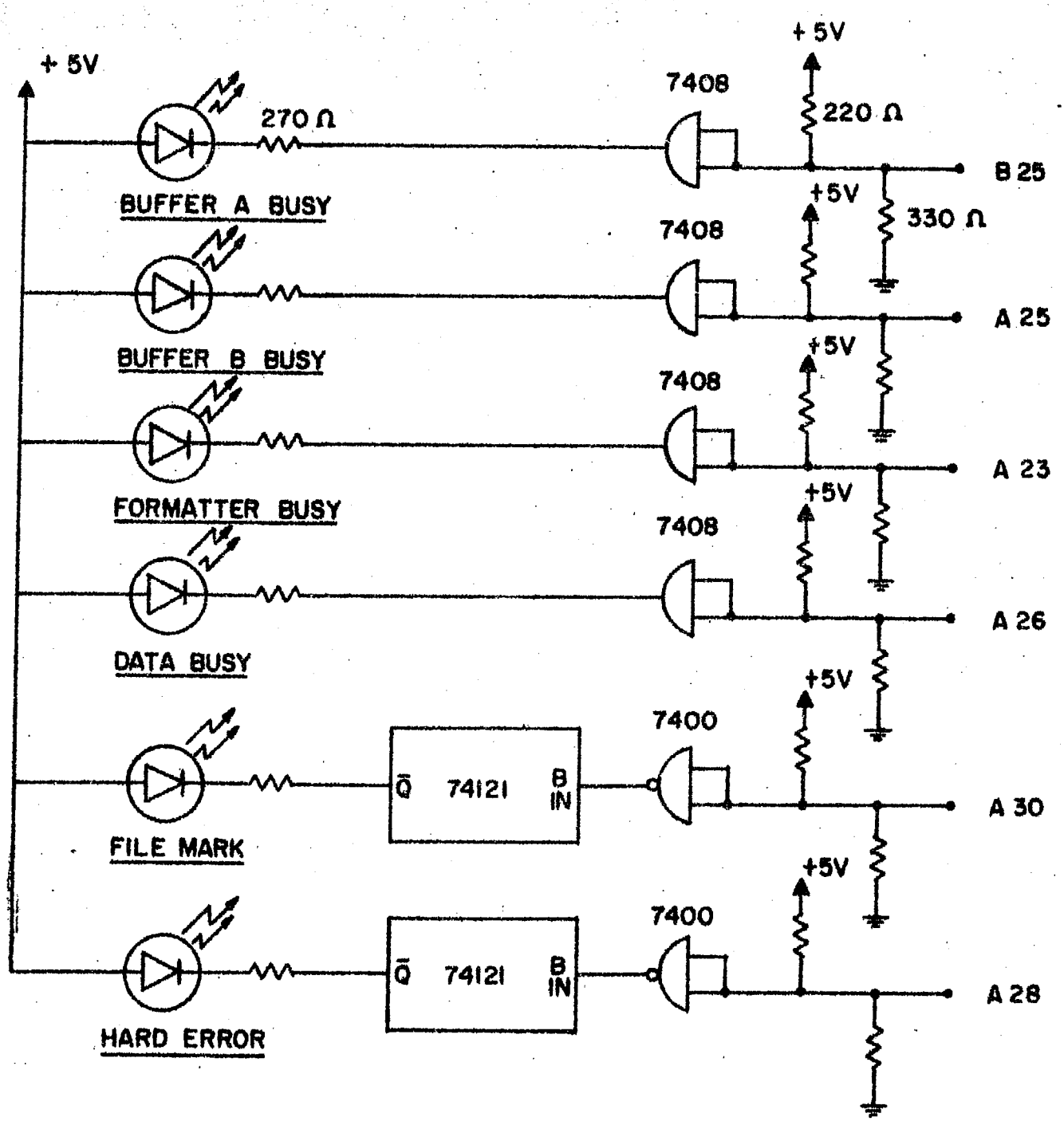

FIG. 3: STATUS DISPLAY

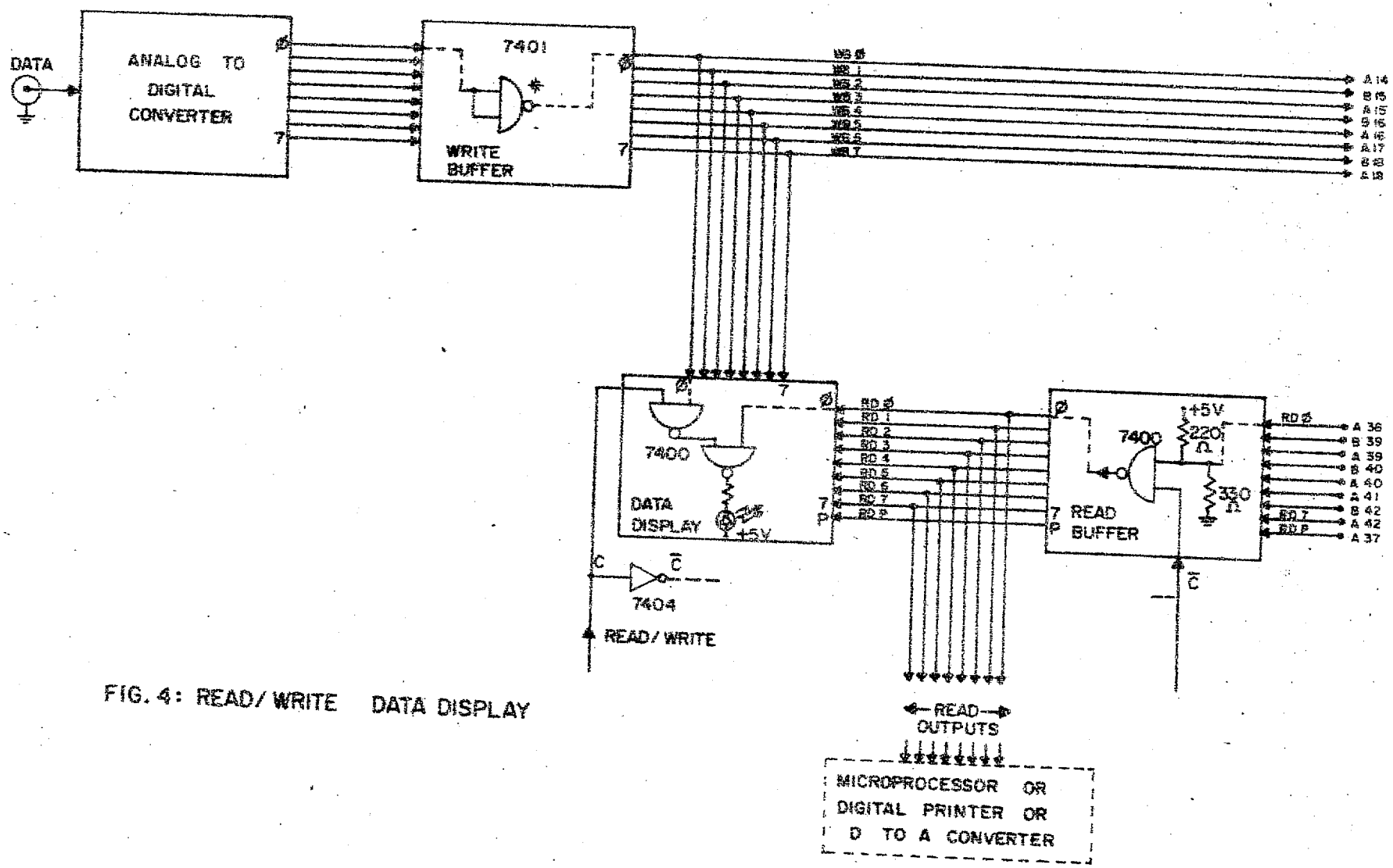

FIG. 4: READ/WRITE DATA DISPLAY

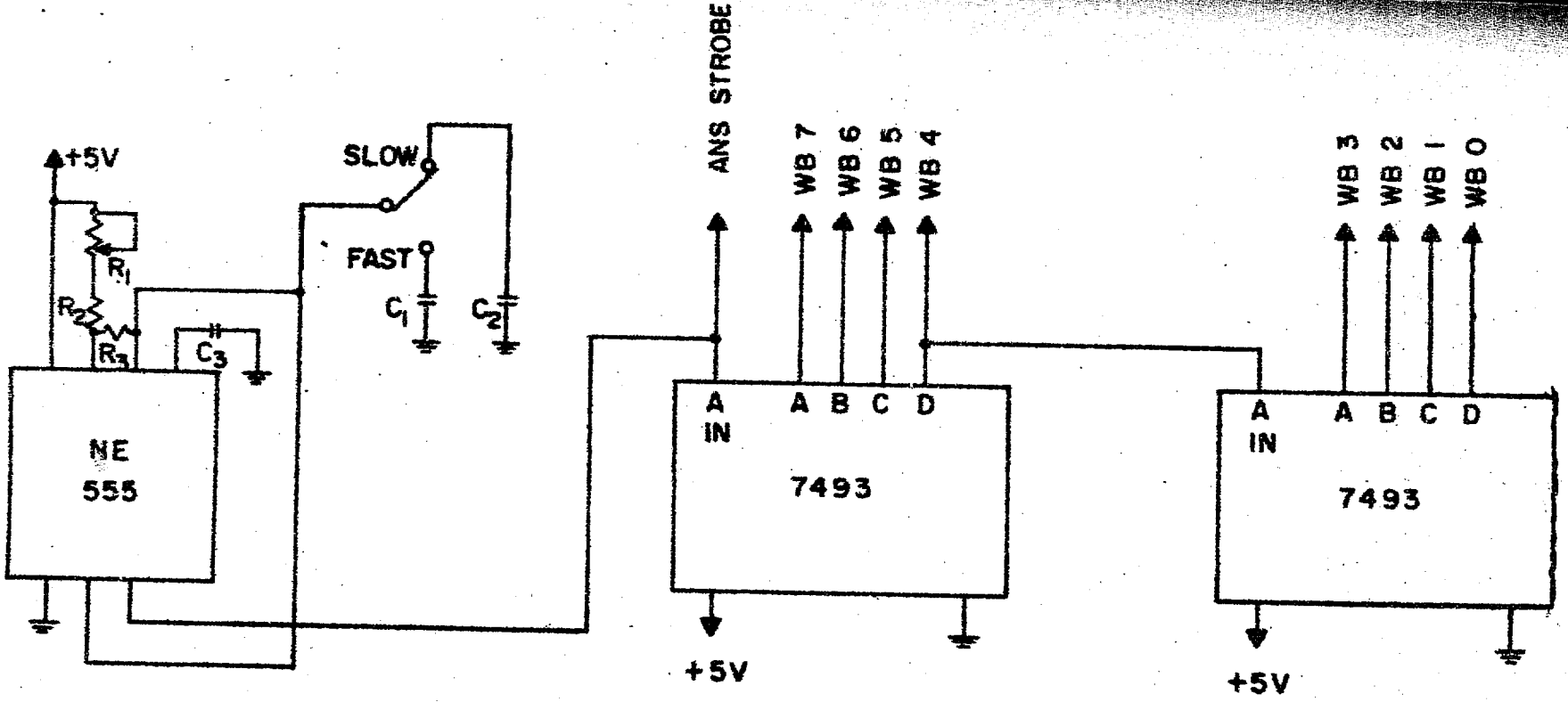

FIG. 5. TEST CIRCUIT

```
                C       THIS PROGRAM GIVES PRINTOUT IN HEXADECIMAL
                C       CHARACTE..3 WHEN THE DIGITAL TAPE
                C       PREPARED ON THE CCT INTERFACE IS READ IN IBM 360/44
0001                    DIMENSION IA(1024),IB(1024)
0002                    LOGICAL*1 XA(4)
0003                    CALL SETBUF(1024)
0004                    DO 201 JK=1,40
0005                    CALL RDTP(IB,1024,&301)
0006            301     PRINT 601,IB
0007            601     FORMAT(16(2X,Z2))
0008            201     CONTINUE
0009                    END

0001                    SUBROUTINE RDTP(IA,LEN,*)
0002                    IMPLICIT INTEGER(A-Z)
0003                    DIMENSION IA(LEN)
0004                    LOGICAL*1 IB(4096),KA(4)
0005                    EQUIVALENCE(KA,JJ)
0006                    CALL SETBUF(LEN,&601)
0007                    READ(2,301)(IB(I),I=1,LEN)
0008            301     FORMAT(32(12BA1))
0009                    JJ=0
0010                    DO 401 I=1,LEN
0011                    KA(4)=IB(I)
0012            401     IA(I)=JJ
0013                    RETURN
0014            601     STOP 601
0015                    END
*
```

Fig. 6. Programme for computer readout

D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F
80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F
80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF
00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F

Fig. 7. Computer printout