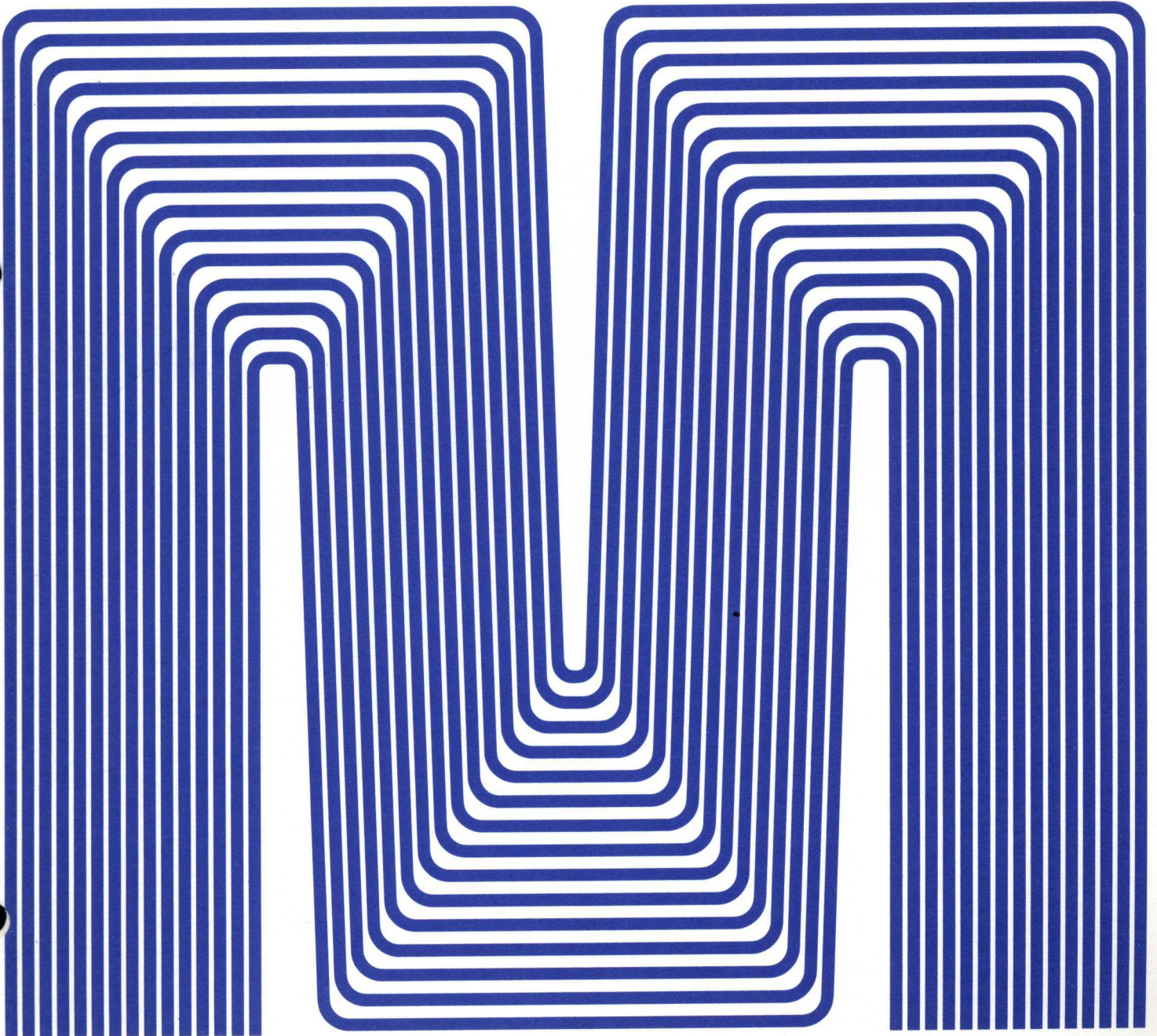


MicroSystems Inc.

FEB 13 1970

Micro 810 Computer

**MAP810 Assembly
Program
Tape Editor Program
Teletype Operating
System (TOS)**



MICRO 810 COMPUTER

MAP810 ASSEMBLY PROGRAM

TAPE EDITOR PROGRAM

TELETYPE OPERATING SYSTEM (TOS)

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MAP810 ASSEMBLY PROGRAM

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1. INTRODUCTION

The Micro Assembly Program (MAP810) is a two pass symbolic assembly program which allows for assembly of absolute binary programs for and on the MICRO 810 Computer. The assembler is contained in 4096 bytes, including 200 names, and is designed to operate using an ASR 33 Teletype with paper tape reader and punch. Other versions of the program permit use of high speed paper tape reader and/or punch, card reader, or line printer.

On the first pass, the source program is read and the assembler builds a name table and assigns a value to each symbol. Undefined names are detected during this pass and are typed out at the end of the pass. Multi-defined names, syntax, and format errors detected during the pass cause the source statement and error flags to be typed out when the statement in error is processed.

During the second pass, the assembler reads the source program again and generates a binary object paper tape and a program listing. Each line of the listing contains the hexadecimal address at the first byte of the instruction, the hexadecimal value of all bytes of the instruction, error flags, and the source statement.

The MAP810 assembly language includes the following features:

- Address Arithmetic -- Decimal and hexadecimal numbers, symbolic addresses, and arithmetic expressions.
- Data Definitions -- Variable precision integer, address expressions, character constants, and literals may be designated.
- Listing Control -- The format of the listing is automatically controlled and comment statements may be included.
- Diagnostics -- Diagnostics for source program errors are included in the output listing.

2. SOURCE LANGUAGE

The source language is a sequence of symbolic instructions called statements, which are punched on paper tape or cards. Each statement may consist of from one to four entries: a name field, an operation field, an operand field, and a comments field. The maximum length of a statement is 72 characters.

Source program paper tapes that are prepared off-line on a teletype may be in a free form format. This means they may have one or more spaces between fields. All paper tape statements must be terminated by a carriage return, line feed, and two rub-out characters. If the first character of a statement is a left arrow ←, it is treated as an end of tape indicator and the assembler will halt to permit another tape to be inserted before continuing. This allows large programs to be separated into several smaller tapes to make editing easier. Source program tapes may also be prepared using the Tape Editor; the tapes will be in a compressed format that removes strings of blank characters.

STATEMENT FORMAT

Name Field

The name field entry is a symbol composed of from one to six characters starting with character position 1 and terminating with the first blank. Only the first three characters are retained, therefore, they must be unique. The first character of a symbol is alphabetic or period; subsequent characters may be alphabetic, numeric or a period. A name entry is usually optional and the type of instruction determines the legal content of the name field. The symbol takes on the current value of the assembler's location counter unless assigned another value by an assembler instruction. When an asterisk (*) appears in character position 1, the remainder of the line is considered as comment and is not processed by the assembler except to place it on the listing.

Operation Field

The operation field entry consists of a three character mnemonic operation code specifying the machine or assembler instruction. Certain memory referencing instruction modes use special symbols suffixed to the mnemonic, while all other instructions are followed by a blank. The field begins with the first non blank character following the name field in paper tape or with column 8 in cards, and is a minimum of 4 characters in length. DS and DC assembler instructions are considered to have a blank as a third character of the mnemonic.

Operand Field

The operand field entries identify and describe data to be acted upon by instructions as, for example, memory locations, or literals. One or more operands may be written, depending on the needs of the instruction. Entries are separated by commas, and no blanks may appear in the field. The operand field may start anywhere following the operation field. When punched in cards, column 14 is the normal starting column. It is terminated by the first blank.

Comments Field

Comments describing the information about the program may be inserted between the end of the operand field and column 72. All characters, including spaces, may be used in writing a comment. If the listing is printed on a teletype, only the first 53 characters of the source line are printed.

OPERAND FIELD EXPRESSIONS

Expressions in the operand field are made up of one or more terms which are connected by + and - arithmetic operators. No parenthetical expressions are allowed. Each term of the expression represents a value. Values may be assigned by the assembler program (symbols), or they may be inherent in the term itself (constants). The range of values depends on the operand and the instruction. Address expressions for relative type addressing are written as if they are not relative. The assembler will convert these expressions to a relative displacement.

Symbols

A symbol is composed of one to six characters, but only the first three are recognized, and therefore must be unique. The first character must be alphabetic or period; subsequent characters may be numeric, alphabetic, or period. Imbedded blanks are not allowed and the assembler stops scanning the symbol with the first character which is not alphanumeric or a period. All symbols, except the special symbols * and **, used in an operand field, must be defined by a single appearance in the name field of statement within the program.

Special Symbols

The special symbol * represents the momentary value of the assembler's location counter. It may be used as any other symbol in an expression but must never appear in the name field. When used in the operand field of a multi-byte instruction, it will assume the value of the address of the first byte of the instruction.

The special symbol ** may be used to indicate that the field will be changed during program execution. Normally it is used by itself without any other terms in the expression. The symbol yields a zero value and the byte length is governed by the usage.

Constants

The values of the constant terms are not assigned by the assembler program but are inherent in the terms. There are two types of constant terms: decimal and hexadecimal.

a. Decimal Constant

A decimal constant is an unsigned decimal number. The value must be less than 65,536.

b. Hexadecimal Constant

A hexadecimal constant is an unsigned hexadecimal number of up to four characters written as a sequence of hexadecimal digits. The digits are enclosed in single quotation marks and preceded by the letter X. Each hexadecimal digit represents a four-bit binary number. The characters A through F are used to identify the hexadecimal integers 10 through 15.

H – Half Word Integer Literal

A half word integer constant is written as a signed or unsigned decimal number in the range +127 to –128. The number is converted to its binary equivalent and assembled into a single byte if a variable operand length instruction otherwise it is assembled into a two byte operand and right justified with leading zeros.

F – Full Word Integer Literal

A full word integer constant is written as a signed or unsigned decimal number in the range $+2^{15}-1$ to -2^{15} . The number is converted to its binary equivalent and assembled in two eight bit bytes.

E – Extended Word Integer Literal

An extended word integer constant is written as a signed or unsigned decimal number in the range $+2^{23}-1$ to -2^{24} . The number is converted to its binary equivalent and assembled in three eight bit bytes if the instruction is a variable operand length type; otherwise two bytes of zero are assembled and an 'A' diagnostic is placed in the listing.

D – Double Word Integer Literal

A double word integer constant is written as a signed or unsigned decimal number in the range $+2^{31}-1$ to -2^{31} . The number is converted to its binary equivalent and assembled in four eight bit bytes if the instruction is a variable length type; otherwise two bytes of zero are assembled and an 'A' diagnostic is placed in the listing.

A – Address Constant

A 16-bit address constant is written as an expression consisting of decimal numbers, hexadecimal numbers and symbols. The value of the expression must be in the range 0 to 65535 and any symbol which is undefined will result in a diagnostic error flag and a zero value. If the location counter symbol * appears in the address expression it will assume the value of the address of the first byte of the instruction. The index flag in bit 15 of the address word is set to a 1-bit by following the expression with a second operand consisting of the character X. The two operands are separated by a comma. An address constant may also be written without the A type identifier and quotes.

X – Hexadecimal Literal

A hexadecimal constant consists of one to eight hexadecimal digits (0-9 and A-F). If the instruction is a variable word length operand type, the number of bytes assembled is determined by the number of digits. When the number of digits is odd a leading zero is added. If the instruction is a fixed word length type, the constant is right justified with leading zeros in two eight-bit bytes, and when the number of digits is greater than four, an 'A' diagnostic is placed in the listing.

C – Character Literal

A character constant consists of a sequence of one to four characters, excluding the single quotation mark. Each character is converted to its ASCII value which is assembled as a single eight bit byte. If the instruction is a fixed word length type an 'A' diagnostic and zero value constant occurs if the number of characters is greater than two; if only a single character is included it is assembled right justified with leading zeros in two eight-bit bytes.

3. MACHINE INSTRUCTIONS

Machine language instructions occupy one to five bytes of memory. The first byte contains the operation code and addressing mode code. The instruction is expressed in the assembly language by a three character mnemonic code in the operation field. Memory referencing instructions have eight addressing modes which occupy eight consecutive instruction codes. The addressing mode is expressed by the value of the address expression in the operand field and by a special symbol suffixed to the mnemonic operation code.

If the instruction is a memory referencing literal (mode 7) type, the second through fifth bytes of the instruction hold a literal which is expressed as a constant in the operand field. The types of constants and the way in which they are assembled is described later in this section under Mode 7. In general the literals are written and assembled in a manner similar to the DC assembler instruction.

Non-literal memory referencing instructions require 0, 1, or 2 bytes following the first byte to hold an address. Modes which make use of one byte for address contain an eight bit address of the first 256 memory locations (page 0), an eight bit signed displacement, or an 8 bit unsigned bias. Modes which make use of two bytes for the address hold a 16-bit address word with an index flag in bit 15.

The shift instructions use the second byte of the instruction to hold an eight bit shift count. The conditional jump instructions use the second byte to hold an eight bit signed displacement.

Examples of the method of writing machine instructions in the assembly language are shown in the sample listing at the end of section 5.

MEMORY ADDRESSING MODES

Each memory referencing instruction has eight addressing modes. The operation of the computer in each of these modes is explained in the MICRO 810 Computer Reference Manual. All addresses for modes 0-3 are written without regard for the mode to be used. The assembler will convert to relative addresses if the evaluated address is not in page 0.

Mode 0: Direct Page 0

When the evaluated address in the operand field is less than 256 and the mnemonic operation code is suffixed with a blank, the instruction is assembled as mode 0, and an eight bit address is placed in the second byte of the instruction.

Mode 1: Direct Relative

When the evaluated address in the operand field is greater than or equal to 256 and the mnemonic operation code is suffixed with a blank, the instruction is assembled as mode 1. If the address minus the location of the first byte of the instruction minus two is in the range +127 to -128 this value is assembled into the second byte of the instruction; otherwise a zero value is assembled and an 'R' diagnostic flag is placed in the listing.

Mode 2: Indirect Page 0

When the evaluated address in the operand field is less than 256 and the mnemonic operation code is suffixed with an *, the instruction is assembled as mode 2, and an eight bit address is placed in the second byte of the instruction.

Mode 3: Indirect Relative

When the evaluated address in the operand field is greater than or equal to 256 and the mnemonic operation code is suffixed with an *, the instruction is assembled as mode 3. If the address minus the location of the first byte of the instruction minus two is in the range +127 to -128 the value is assembled into the second byte of the instruction; otherwise a zero value is assembled and an 'R' diagnostic flag is placed in the listing.

Mode 4: Indexed

When the instruction mnemonic operation code is suffixed with -, the instruction is assembled as mode 4 in a single byte instruction. The operand field is disregarded.

Mode 5: Indexed With Bias

When the instruction mnemonic operation code is suffixed with a +, the instruction is assembled as mode 5. If the value of the operand is less than 256 it is assembled into the second byte of the instruction; otherwise a zero value is assembled and an 'A' diagnostic flag is placed in the listing.

Mode 6: Extended Address

When the instruction mnemonic operation code is suffixed with a /, the instruction is assembled as mode 6. The value of the first operand is assembled as a 16-bit address in the second and third bytes of the instruction. If the character X preceded by a comma, is entered as a second operand the index flag in bit 15 of the address word is set to a 1-bit.

Mode 7: Indirect Extended Address (Jump and Return Jump)

When the instruction mnemonic operation code is suffixed with an =, the instruction is assembled as mode 7. The value of the first operand is assembled as a 16-bit address in the second and third bytes of the instruction. If the character X, preceded by a comma, is entered as a second operand the index flag in bit 15 of the address word is set to a 1-bit.

Mode 7: Literal

When the instruction mnemonic operation code is suffixed with an =, the instruction is assembled as mode 7 and the value of the operand field is assembled into the 1-4 bytes following the first byte. The length of a literal for the variable word length operand instructions (third character of mnemonic is V) depends on the literal type or the number of digits or characters. The programmer must assure that the length of these operands is consistent with the word length mode in effect. Instruction which are fixed word length operand type always assemble a two byte literal. A literal is enclosed in single quotation marks and is preceded by a single type identifier character. A literal without a type identifier and quotes is evaluated as a 16-bit address type.

4. ASSEMBLER INSTRUCTIONS

Seven assembler instructions are included for control of the assembly process and the output listing.

ORG – Set Location Counter

The ORG assembler instruction alters the setting of the location counter. The name field entry, if any, will be assigned the value of the program counter after it is altered. The operand field of ORG must contain an expression whose value will be placed in the location counter. All symbols in the expression must have been previously defined when the instruction is first encountered. The next instruction which places object code in the program is forced to begin a new object card.

EQU – Equate Symbol

The EQU assembler instruction is used to define a symbol by assigning to it the value of the operand field. Any symbols appearing in the expression must have been previously defined when the instruction is first encountered. A name field entry must be present.

SET – Set Symbol

The SET assembler instruction assigned the value of the operand field to the symbol in the name field. Any symbols appearing in the operand field must have been previously defined when the instruction is first encountered. A name field entry must be present and may be a symbol previously defined. A multi-defined error cannot occur.

DC – Define Constant

The DC assembler instruction is used to provide constant data in memory. Each statement specifies only one constant. The constants which may be specified are:

8-bit decimal, 16-bit decimal, 24-bit decimal, 32-bit decimal, address, hexadecimal, and character.

A constant is enclosed in single quotation marks and is preceded by a single type identifier character. A constant without a type identifier and quotes is evaluated as a 16-bit address type. The method of expressing constants for the DC instruction is the same as for literals with the variable word length memory referencing instructions. The seven constant identifiers and a description of each follows:

H – Half Word Integer Constant

A half word integer constant is written as a signed or unsigned decimal number in the range +127 to –128. The number is converted to its binary equivalent and assembled as a single eight-bit byte.

F – Full Word Integer Constant

A full word integer constant is written as a signed or unsigned decimal number in the range $+2^{15}-1$ to -2^{15} . The number is converted to its binary equivalent and assembled in two eight-bit bytes.

E – Extended Word Integer Constant

An extended word integer constant is written as a signed or unsigned decimal number in the range $+2^{23}-1$ to -2^{24} . The number is converted to its binary equivalent and assembled in three eight-bit bytes.

D – Double Word Integer Constant

A double word integer constant is written as a signed or unsigned decimal number in the range $+2^{31}-1$ to -2^{31} . The number is converted to its binary equivalent and assembled in four eight-bit bytes.

A – Address Constant

A 16-bit address constant is written as an expression consisting of decimal numbers, hexadecimal numbers and symbols. The value of the expression must be in the range 0 to 65535 and any symbol which is undefined will result in a diagnostic error flag and a zero value. If the location counter symbol * appears in the address expression it will assume the value of the address of the first byte of the instruction. The index flag in bit 15 of the address word is set to a 1-bit by following the expression by a second operand consisting of the character X. The two operands are separated by a comma. An address constant may also be written without the A type identifier and quotes.

X – Hexadecimal Constant

A hexadecimal constant consists of one to eight hexadecimal digits, (0-9 and A-F). The number of bytes assembled is determined by the number of digits. If the number of digits is odd a leading zero is added.

C – Character Constant

A character constant consists of a sequence of characters, excluding the single quotation mark. The constant must be terminated by column 72. Each character is converted to its ASCII value and assembled as a single eight bit byte.

DS – Define Storage

The DS instruction is used to reserve areas of memory and to assign names to these areas. The value of the operand field specifies the number of bytes to be reserved. A zero value in the operand field caused no bytes to be reserved, but causes the symbol in the name field to take on the current value of the location counter. No object code is assembled into the binary program and the next instruction which does place code in the program is forced to begin a new object card.

END – **End Assembly**

The **END** assembler instruction terminates the assembly of a program and must be the last statement in a source program.

5. ASSEMBLY LISTING

A listing generated during the second pass of the assembly supplies a side by side representation of source statements, generated object code, memory address of the first byte of the instruction, and diagnostic messages. The format locates the various items at fixed positions across the printed page to produce a columnar organization. Print positions for listing are shown below.

FORMAT

Printer Columns	Contents
1 - 4	Memory address of first byte of assembled instruction.
6 - 15	Hexadecimal digits of up to five bytes of object code.
17 - 18	Diagnostic message identifiers.
20 - 25	Name field of source statement.
27 - 29	Operation code of source statement.
30	Address mode identifier if applicable.
33 - 72	Operand field and comment section.

Source paper tapes that are punched in the free form or compressed format will be listed in above fixed form format.

ERROR FLAGS

Diagnostic messages are indicated by single character identifiers appearing in columns 17 or 18. If more than two errors are detected for a single source statement, only the last two encountered will be listed. The diagnostic symbols are as follows:

A — Address Error

This error occurs when an address expression in the operand field is incorrectly written or the value is out of range for one of the operands. An error flag will occur for each operand in error or out of range.

F — Name Table Full

This error occurs when the name table is full. The name or operand in this statement was not entered into the table.

M – Multidefined Symbol Error

This error occurs when the symbol in the name field has been previously defined by appearing in the name field of another instruction.

N – Name Field Error

This error flag occurs when the symbol in the name field starts with a character other than alphabetic or period or contains a non-alphanumeric or non-period character.

O – Operation Mnemonic Error

This error occurs when the assembler does not recognize the contents of the operation field starting in column 8. A two byte zero value is assembled to allow patching.

R – Range Error

This error occurs when the operand address of a relative addressing mode memory reference instruction or a Conditional Jump instruction is not in the range of +127 to -128 bytes from the location of the next instruction.

U – Undefined Symbol Error

This error occurs when the symbol encountered in an expression of the operand field is not defined by an appearance in the name field.

SAMPLE LISTING

The sample listing on the next page shows the format of the listing and provides examples of how to write each instruction type, literals, constants, and assembler instructions. Six types of error conditions are also illustrated.

```

3          ** CONTROL INSTRUCTIONS
0000 00          START HLT          NO OPERAND FOR CONTROL
0001 34          NOP
4          ** CONDITIONAL JUMP INSTRUCTIONS
0002 1000       CJ    JOV    **2    ZERO DISPLACEMENT
0004 11FC          JAZ    2        NEGATIVE DISPLACEMENT
0006 1EFA          NAB CJ          OPERAND MAY START HERE
0008 1F00       R    NAX    **300   OUT OF RANGE
000A 0000       O    SSS    CJ+2    ILLEGAL MNEMONIC
7          ** SHIFT INSTRUCTIONS
000C 2005       ALP    LLA    5
8          000E 2200       A          LLL    -5    NEGATIVE COUNT ILLEGAL
0010 280C          ALA    TEN+2     MAY BE AN EXPRESSION
9          0012 2E10       ALPHA ARL  X'10'    NAME IS MULTI-DEFINED
0014 2800          ALA    **        DUMMY SHIFT COUNT
10         ** INPUT/OUTPUT
0016 3000       BETA  IBS    0,0    UNUSED OPERAND FIELD
11         0018 3142          IBA    2,2     ORDER AND DEVICE ADDRESS
001A 3B848146    OBM    4,4,BUF,X    I/O MEMORY INDEXED
12         ** REGISTER OPERATE
001E 41          XRA          NO OPERAND NEEDED
13         ** NON LITERAL MEMORY REFERENCING INSTRUCTIONS
001F E01F       N 123456 LDA    *        MODE 0, NAME ERROR
14         0100          ORG    256     ASSEMBLER INSTRUCTION
0100 F100       .DOT  STA    **2     MODE 1
15         0102 8200       U          LDX* OOPS    MODE 2, NAME UNDEFINED
0104 8345          LDX* BUF+5     MODE 3
16         0106 8C          A23456 STX-   MODE 4, NO OPERAND FIELD
0107 AD1E          ADV+   30        MODE 5
17         0109 96813A      MUL/  SAM,X    MODE 6, WITH INDEX FLAG
010C EE013A      LDV/  SAM        MODE 6 NO INDEX FLAG
18         ** FIXED WORD LENGTH LITERALS (MODE 7)
010F E700FF      LDA=  H'-1'    TRUNCATED OPERAND
19         0112 F70000      SPOT  STA=  **        A REG. STORED IN SPOT+1
0115 970000       A          MUL=  E'100'    ILLEGAL WITH FIXED WORD
20         0118 E7000C      M          LDA=  A'ALPHA'    ADDRESS TYPE
011B E7800C      M          LDA=  A'ALPHA,X'    WITH INDEX FLAG
21         011E 87000C      M          LDX=  ALPHA    ADDRESS TYPE WITHOUT A'
0121 C700C1      CPA=  C'A'    TWO BYTE WITH LEADING 0
22         0124 D700FF      ANA=  X'FF'    HEX RIGHT JUSTIFIED
23         ** VARIABLE WORD LENGTH LITERALS (MODE 7)
0127 EF013A      LDV=  SAM        TWO BYTE ADDRESS LITERAL
012A AF000003FF  ADV=  D'1023'    FOUR BYTE INTEGER
24         012F DF09ABCDEF  ANV=  X'9ABCDEF'    LENGTH SET BY COUNT
0134 CFC1        CPV=  C'A'    SINGLE BYTE BY COUNT
25         ** ASSEMBLER INSTRUCTIONS
26         0008          TEN    EQU    8        SYMBOL IS EQUATED TO 8
000A          TEN    SET    10        SET ALLOWS MULTI-DEFINED
27         0136 800B          DC    A'TEN+2-1,X'    ADDRESS CONSTANT
0138 800B          DC    TEN+2-1,X    ADDRESS CONSTANT
28         013A D4C8C9D3      SAM   DC    C'THIS IS A DC'
013E A0C9D3A0
29         0142 C1A0C4C3
0146 0004       BUF    DS    4        FOUR BYTES ARE RESERVED
30         014A 0000          DC    **        CHANGED DURING EXECUTION
          ** JUMP AND RETURN JUMP INSTRUCTIONS
31         014C 66000C      M          JMP/  ALPHA    MODE 6, EXTENDED
014F 67800C      M          JMP=  ALPHA,X    MODE 7, IND EXT INDEXED
32         0152 000C       M          END    ALPHA    LOADER EXECUTION ADDRESS

```

FIGURE 1. SAMPLE LISTING

6. BINARY PAPER TAPE FORMAT

The binary paper tape generated by the assembler or TOS (see figure 2), is formatted to suppress printing when using an ASR 33 teletype punch. A byte of information is punched into two consecutive frames of tape. Each frame will contain one hexadecimal (four binary bits), punched in channels 4-1. Hexadecimal numbers greater than 4 have channel 5 punched to control print suppression.

The binary tape is divided into records with each record containing a record mark, a record length byte, a load or execution address, up to 128 bytes of data, address, and a check sum as follows:

- Record Mark — A record mark is a blank frame and normally follows three record separator frames of all ones. The record separator provides a visual aid for locating the beginning of an individual record. Any frame with a 1-bit in channel eight, appearing after the checksum and preceding the record mark, is treated as separator and is ignored by the loader.
- Record Length Byte — A byte containing a count of the number of data bytes in the record follows the record mark. If the record contains zero bytes, the following address is taken as a program execution address; otherwise the address is the address where the first byte of the record is loaded. Normally the record length will be equal to or less than 128 data bytes.
- Address Word — A pair of bytes following the record length specified: (1) the address where the data is to be loaded if the record length is not zero, and (2) the address where the program starts execution if the record length is zero.
- Data Byte — Eight bit value to be placed into memory.
- Checksum Byte — The checksum is the last byte of the record and is followed by record separator frames. This byte contains the sum of all data bytes, the record length byte, and the address bytes. The summation is made, with 8-bit precision, with overflow added into the least significant bit.

DS and ORG assembler instructions cause new records to be started since a new load address is required. No information is loaded for the memory locations reserved by a DS instruction.

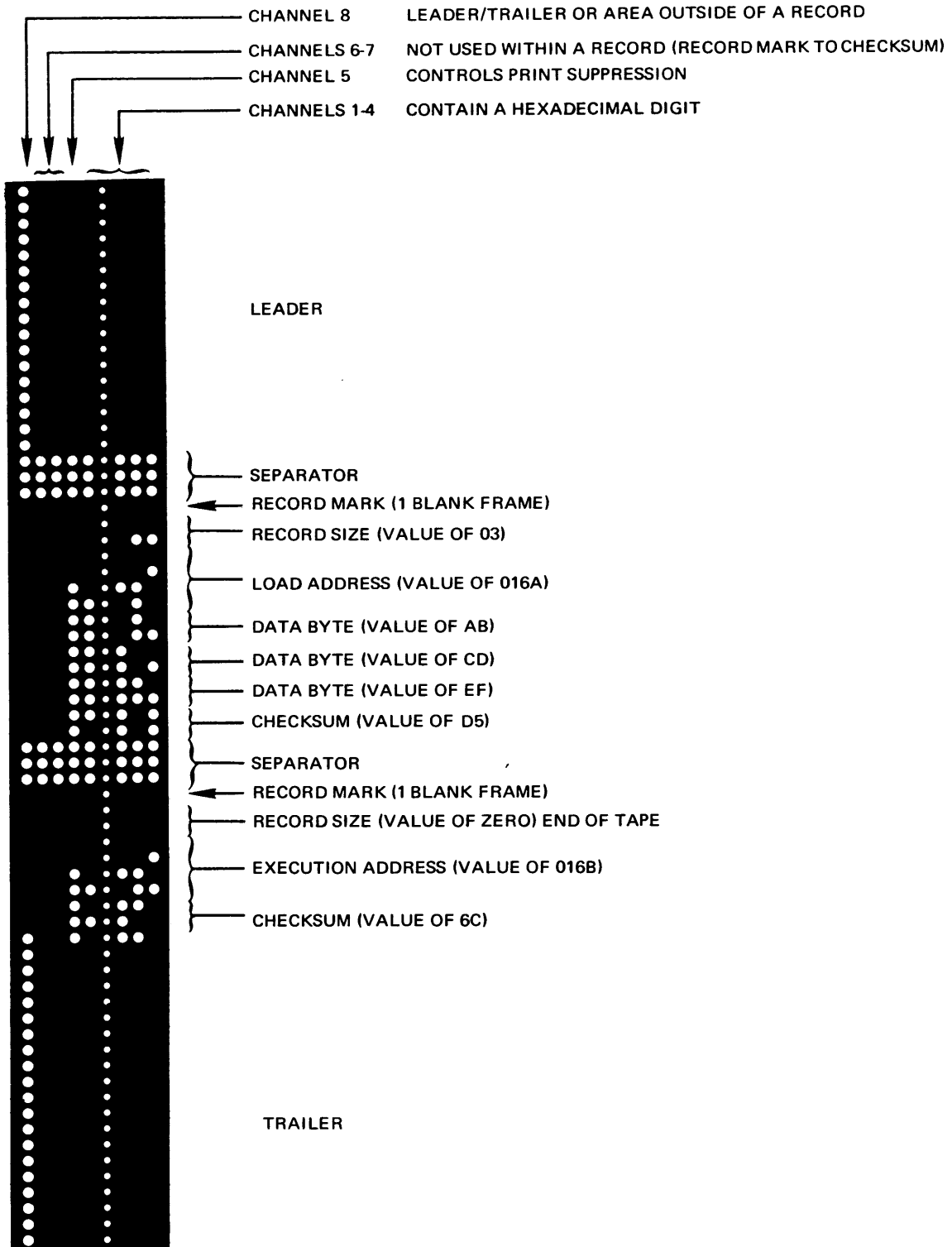


FIGURE 2. BINARY PAPER TAPE FORMAT

7. OPERATING INSTRUCTIONS

Loading the assembler by the bootstrap and basic loaders

1. Place the TTY in the off-line mode, place the reader control lever to the "free" position and enable the teletype reader. Type control and Q.
2. Place the TTY in the on-line mode and insert the program tape in the reader with the first rub-out character at the read station. Set the reader control lever in the stop (center) position.
3. Set the front panel sense switches as follows:
 - Sense switch 1: off for serial TTY interface
on for parallel TTY interface.
 - Sense switch 2: must be off.
 - Sense switch 3: must be off.
 - Sense switch 4: must be on. This selects the bootstrap loader whenever the run switch is selected and was preceded by a reset.
4. Press the reset and the run switches and the system will wait for the teletype reader to be started.
5. Press the TTY reader lever to the start position.

When the basic loader is loaded and operating properly, the teletype page printer mechanism will chatter whenever a record separator passes the read station. This is caused by the issuance of reader off and a reader on codes between records.

If a checksum error is found, the message 'CE' is typed and the system will halt. Another attempt to properly load the record may be accomplished by backing up the tape to the previous record separator (indicated by 3 successive rub-outs), placing the reader control lever in the stop (center) position, and pressing the run switch on the front console. When the tape is properly loaded, the reader will be stopped, and control will transfer to the loaded program.

If another input device is available on the system, it may be used to load the program. The basic loader for that device is supplied as a separate paper tape and is read through the teletype reader by the previously described procedure. Following the loading of this short tape, the program will be automatically loaded via the other device.

Loading the assembler by the R operator of TOS

Unroll about 30 inches of the program tape to bypass the basic loader and locate the leader (any frame with channel 8 present) of the formatted tape. Insert the tape into the reader with any part of the leader at the read station and set the reader control lever to center position. Typing an R will start the loading. A checksum is calculated for each record loaded

and if it doesn't equal the checksum read with record, the letters 'CE' will be typed and control will return to TOS. By backing up the tape to the previous separator and typing an R, another attempt may be made to load the tape.

Source Program Assembly

At the start of each pass, a message indicating the pass number will be typed. Insert the source program into the input device and type a carriage return to start each pass. When fan fold print forms are used, proper vertical alignment may be attained before typing the carriage return. Place the page perforation two lines below the top edge of the teletype ribbon.

When using an ASR33 teletype, insure that the punch mechanism has not been left enabled due to a previous depression of the 'lock on' button located on the punching unit. This will mechanically inhibit the function of punch on and punch off codes and result in the punching of 8 level tapes whenever the unit is printing. To correct this, place the power switch in the off-line (local) mode, depress the 'unlock' button on the punching unit, type control and T, and return the teletype to the on-line mode.

APPENDIXES

APPENDIX A

MICRO 810 INSTRUCTIONS

Operation Code	Mnemonic	Operand	Instruction Name
Control			
00	HLT		Halt
01	TRP		Trap
02	ESW		Enter Sense Switches
03	PMP		Protect Memory Page
04	DIN		Disable Interrupt System
05	EIN		Enable Interrupt System
06	DRT		Disable Real Time Clock
07	ERT		Enable Real Time Clock
08	RO1		Reset Overflow and Set Word Length to 1
09	RO2		Reset Overflow and Set Word Length to 2
0A	RO3		Reset Overflow and Set Word Length to 3
0B	RO4		Reset Overflow and Set Word Length to 4
0C	SO1		Set Overflow and Set Word Length to 1
0D	SO2		Set Overflow and Set Word Length to 2
0E	SO3		Set Overflow and Set Word Length to 3
0F	SO4		Set Overflow and Set Word Length to 4
34	NOP		No Operation
Conditional Jump			
10	JOV	a	Jump if Overflow Set
11	JAZ	a	Jump if A Equal to Zero
12	JBZ	a	Jump if B Equal to Zero
13	JXZ	a	Jump if X Equal to Zero
14	JAN	a	Jump if A Negative
15	JXN	a	Jump if X Negative
16	JAB	a	Jump if A Equals B
17	JAX	a	Jump if A Equals X
18	NOV	a	Jump if Overflow Not Set
19	NAZ	a	Jump if A Not Equal to Zero
1A	NBZ	a	Jump if B Not Equal to Zero
1B	NXZ	a	Jump if X Not Equal to Zero
1C	NAN	a	Jump if A Not Negative
1D	NXN	a	Jump if X Not Negative
1E	NAB	a	Jump if A Not Equal to B
1F	NAX	a	Jump if A Not Equal to X

Operation Code	Mnemonic	Operand	Instruction Name
Shift			
20	LLA	n	Logical Left A
21	LLB	n	Logical Left B
22	LLL	n	Logical Left Long
24	LRA	n	Logical Right A
25	LRB	n	Logical Right B
26	LRL	n	Logical Right Long
28	ALA	n	Arithmetic Left A
29	ALB	n	Arithmetic Left B
2A	ALL	n	Arithmetic Left Long
2C	ARA	n	Arithmetic Right A
2D	ARB	n	Arithmetic Right B
2E	ARL	n	Arithmetic Right Long
Input/Output			
30	IBS		Input Byte Serially
31	IBA	f,d	Input Byte to A
32	IBB	f,d	Input Byte to B
33	IBM	f,d,a or a,X	Input Byte to Memory
38	OBS		Output Byte Serially
39	OBA	f,d	Output Byte from A
3A	OBB	f,d	Output Byte from B
3B	OBM	f,d,a or a,X	Output Byte from Memory
Register Operate			
40	ORA		OR B with A
41	XRA		Exclusive – OR B with A
42	ORB		OR A with B
43	XRB		Exclusive – OR A with B
44	INX		Increment X
45	DCX		Decrement X
46	AWX		Add Word Length to X
47	SWX		Subtract Word Length from X
48	INA		Increment A
49	INB		Increment B
4A	OCA		One's Complement A
4B	OCB		One's Complement B
4C	TAX		Transfer A to X
4D	TBX		Transfer B to X
4E	TXA		Transfer X to A
4F	TXB		Transfer X to B

Operation Code	Mnemonic	Operand	Instruction Name
Memory Reference			
60	JMP	a or a,X or l	Jump
68	RTJ	a or a,X or l	Return Jump
70	IWM	a or a,X or l	Increment Word in Memory
78	DWM	a or a,X or l	Decrement Word in Memory
80	LDX	a or a,X or l	Load X
88	STX	a or a,X or l	Store X
90	MUL	a or a,X or l	Multiply
98	DIV	a or a,X or l	Divide
A0	ADA	a or a,X or l	Add to A
A8	ADV	a or a,X or l	Add Variable
B0	SBA	a or a,X or l	Subtract from A
B8	SBV	a or a,X or l	Subtract Variable
C0	CPA	a or a,X or l	Compare A
C8	CPV	a or a,X or l	Compare Variable
D0	ANA	a or a,X or l	And A
D8	ANV	a or a,X or l	And Variable
E0	LDA	a or a,X or l	Load A
E8	LDV	a or a,X or l	Load Variable
F0	STA	a or a,X or l	Store A
F8	STV	a or a,X or l	Store Variable

Operation Code	Mnemonic	Operand	Instruction Name and Mode
Jump and Return Jump Addressing Modes (typical)			
60	JMP	a	Jump — Page 0
61	JMP	a	Jump — Relative
62	JMP*	a	Jump — Indirect Page 0
63	JMP*	a	Jump — Indirect Relative
64	JMP—		Jump — Indexed
65	JMP+	a	Jump — Indexed with Bias
66	JMP/	a or a,X	Jump — Extended Address
67	JMP=	a or a,X	Jump — Indirect Extended Address

Operation Code	Mnemonic	Operand	Instruction Name and Mode
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Other Memory Referencing Addressing Modes (typical)

A0	ADA	a	Add to A – Page 0
A1	ADA	a	Add to A – Relative
A2	ADA*	a	Add to A – Indirect Page 0
A3	ADA*	a	Add to A – Indirect Relative
A4	ADA–		Add to A – Indexed
A5	ADA+	a	Add to A – Indexed With Bias
A6	ADA/	a	Add to A – Extended Address
A7	ADA=	l	Add to A – Literal

Legend of Operand Symbols

- a – Address expression
 - a,X – Address expression with index flag
 - l – Literal
 - f – Device Order
 - d – Device Number
 - n – Shift Count
-

APPENDIX B

STANDARD CHARACTER CODES

SYMBOL	ASCII (HEX)	EBCDIC (HEX)	HOLLERITH (029)	HOLLERITH (026)	SYMBOL	ASCII (HEX)	EBCDIC (HEX)	HOLLERITH (029)	HOLLERITH (026)
blank	A0	40		blank	@	C0	7C	8-4	0-8-2
!	A1	5A		11-8-2	A	C1	C1		12-1
"	A2	7F	8-7	0-8-5	B	C2	C2		12-2
#	A3	7B	8-3	0-8-7	C	C3	C3		12-3
\$	A4	5B		11-8-3	D	C4	C4		12-4
%	A5	6C	0-8-4	11-8-7	E	C5	C5		12-5
&	A6	50	12	12-8-7	F	C6	C6		12-6
'	A7	7D	8-5	8-4	G	C7	C7		12-7
(	A8	4D	12-8-5	0-8-4	H	C8	C8		12-8
)	A9	5D	11-8-5	12-8-4	I	C9	C9		12-9
*	AA	5C		11-8-4	J	CA	D1		11-1
+	AB	4E	12-8-6	12	K	CB	D2		11-2
,	AC	6B		0-8-3	L	CC	D3		11-3
-	AD	60		11	M	CD	D4		11-4
.	AE	4B		12-8-3	N	CE	D5		11-5
/	AF	61		0-1	O	CF	D6		11-6
0	B0	F0		0	P	D0	D7		11-7
1	B1	F1		1	Q	D1	D8		11-8
2	B2	F2		2	R	D2	D9		11-9
3	B3	F3		3	S	D3	E2		0-2
4	B4	F4		4	T	D4	E3		0-3
5	B5	F5		5	U	D5	E4		0-4
6	B6	F6		6	V	D6	E5		0-5
7	B7	F7		7	W	D7	E6		0-6
8	B8	F8		8	X	D8	E7		0-7
9	B9	F9		9	Y	D9	E8		0-8
:	BA	7A	8-2	8-5	Z	DA	E9		0-9
;	BB	5E		11-8-6	[	DB	4F	12-8-7	12-8-5
<	BC	4C	12-8-4	12-8-6	\	DC	4A	12-8-2	0-8-6
=	BD	7E	8-6	8-3	]	DD	5F	11-8-7	11-8-5
>	BE	6E	0-8-6	8-6	↑	DE	6D	0-8-5	8-7
?	BF	6F	0-8-7	12-8-2	←	DF	6A	0-8-2	8-2

APPENDIX C

TELETYPE CONTROL AND TRANSMISSION CODES

FUNCTION	ASCII
NULL	80
SOM (Print on)	81
EAO	82
EOM	83
EOT (Print off)	84
WRU	85
RU	86
BELL	87
FEO	88
H.TAB	89
LINE FEED	8A
V.TAB	8B
FORM	8C
CARRIAGE RETURN	8D
SO	8E
SI	8F
DCO	90
X-ON (Reader on)	91
TAPE (Punch on)	92
X-OFF (Reader off)	93
TAPE OFF (Punch off)	94
ERROR	95
SYNC	96
LEM	97
S0	98
S1	99
S2	9A
S3	9B
S4	9C
S5	9D
S6	9E
S7	9F

APPENDIX D

TABLE OF POWERS OF TWO

2^n	n	2^{-n}
1	0	1.0
2	1	0.5
4	2	0.25
8	3	0.125
16	4	0.062 5
32	5	0.031 25
64	6	0.015 625
128	7	0.007 812 5
256	8	0.003 906 25
512	9	0.001 953 125
1 024	10	0.000 976 562 5
2 048	11	0.000 488 281 25
4 096	12	0.000 244 140 625
8 192	13	0.000 122 070 312 5
16 384	14	0.000 061 035 156 25
32 768	15	0.000 030 517 578 125
65 536	16	0.000 015 258 789 062 5
131 072	17	0.000 007 629 394 531 25
262 144	18	0.000 003 814 697 265 625
524 288	19	0.000 001 907 348 632 812 5
1 048 576	20	0.000 000 953 674 316 406 25
2 097 152	21	0.000 000 476 837 158 203 125
4 194 304	22	0.000 000 238 418 579 101 562 5
8 388 608	23	0.000 000 119 209 289 550 781 25
16 777 216	24	0.000 000 059 604 644 775 390 625
33 554 432	25	0.000 000 029 802 322 387 695 312 5
67 108 864	26	0.000 000 014 901 161 193 847 656 25
134 217 728	27	0.000 000 007 450 580 596 923 828 125
268 435 456	28	0.000 000 003 725 290 298 461 914 062 5
536 870 912	29	0.000 000 001 862 645 149 230 957 031 25
1 073 741 824	30	0.000 000 000 931 322 574 615 478 515 625
2 147 483 648	31	0.000 000 000 465 661 287 307 739 257 812 5
4 294 967 296	32	0.000 000 000 232 830 643 653 869 628 906 25
8 589 934 592	33	0.000 000 000 116 415 321 826 934 814 453 125
17 179 869 184	34	0.000 000 000 058 207 660 913 467 407 226 562 5
34 359 738 368	35	0.000 000 000 029 103 830 456 733 703 613 281 25

APPENDIX E

HEXADECIMAL – DECIMAL INTEGER CONVERSION TABLES

The following tables aid in converting hexadecimal values to decimal values, or the reverse.

Direct Conversion Table

This table provides direct conversion of decimal and hexadecimal numbers in these ranges:

HEXADECIMAL	DECIMAL
000 to FFF	0000 to 4095

For numbers outside the range of the table, add the following values to the table figures:

HEXADECIMAL	DECIMAL
1000	4096
2000	8192
3000	12288
4000	16384
5000	20480
6000	24576
7000	28672
8000	32768
9000	36864
A000	40960
B000	45056
C000	49152
D000	53248
E000	57344
F000	61440

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00_	0000	0001	0002	0003	0004	0005	0006	0007	0008	0009	0010	0011	0012	0013	0014	0015
01_	0016	0017	0018	0019	0020	0021	0022	0023	0024	0025	0026	0027	0028	0029	0030	0031
02_	0032	0033	0034	0035	0036	0037	0038	0039	0040	0041	0042	0043	0044	0045	0046	0047
03_	0048	0049	0050	0051	0052	0053	0054	0055	0056	0057	0058	0059	0060	0061	0062	0063
04_	0064	0065	0066	0067	0068	0069	0070	0071	0072	0073	0074	0075	0076	0077	0078	0079
05_	0080	0081	0082	0083	0084	0085	0086	0087	0088	0089	0090	0091	0092	0093	0094	0095
06_	0096	0097	0098	0099	0100	0101	0102	0103	0104	0105	0106	0107	0108	0109	0110	0111
07_	0112	0113	0114	0115	0116	0117	0118	0119	0120	0121	0122	0123	0124	0125	0126	0127
08_	0128	0129	0130	0131	0132	0133	0134	0135	0136	0137	0138	0139	0140	0141	0142	0143
09_	0144	0145	0146	0147	0148	0149	0150	0151	0152	0153	0154	0155	0156	0157	0158	0159
0A_	0160	0161	0162	0163	0164	0165	0166	0167	0168	0169	0170	0171	0172	0173	0174	0175
0B_	0176	0177	0178	0179	0180	0181	0182	0183	0184	0185	0186	0187	0188	0189	0190	0191
0C_	0192	0193	0194	0195	0196	0197	0198	0199	0200	0201	0202	0203	0204	0205	0206	0207
0D_	0208	0209	0210	0211	0212	0213	0214	0215	0216	0217	0218	0219	0220	0221	0222	0223
0E_	0224	0225	0226	0227	0228	0229	0230	0231	0232	0233	0234	0235	0236	0237	0238	0239
0F_	0240	0241	0242	0243	0244	0245	0246	0247	0248	0249	0250	0251	0252	0253	0254	0255
10_	0256	0257	0258	0259	0260	0261	0262	0263	0264	0265	0266	0267	0268	0269	0270	0271
11_	0272	0273	0274	0275	0276	0277	0278	0279	0280	0281	0282	0283	0284	0285	0286	0287
12_	0288	0289	0290	0291	0292	0293	0294	0295	0296	0297	0298	0299	0300	0301	0302	0303
13_	0304	0305	0306	0307	0308	0309	0310	0311	0312	0313	0314	0315	0316	0317	0318	0319
14_	0320	0321	0322	0323	0324	0325	0326	0327	0328	0329	0330	0331	0332	0333	0334	0335
15_	0336	0337	0338	0339	0340	0341	0342	0343	0344	0345	0346	0347	0348	0349	0350	0351
16_	0352	0353	0354	0355	0356	0357	0358	0359	0360	0361	0362	0363	0364	0365	0366	0367
17_	0368	0369	0370	0371	0372	0373	0374	0375	0376	0377	0378	0379	0380	0381	0382	0383
18_	0384	0385	0386	0387	0388	0389	0390	0391	0392	0393	0394	0395	0396	0397	0398	0399
19_	0400	0401	0402	0403	0404	0405	0406	0407	0408	0409	0410	0411	0412	0413	0414	0415
1A_	0416	0417	0418	0419	0420	0421	0422	0423	0424	0425	0426	0427	0428	0429	0430	0431
1B_	0432	0433	0434	0435	0436	0437	0438	0439	0440	0441	0442	0443	0444	0445	0446	0447
1C_	0448	0449	0450	0451	0452	0453	0454	0455	0456	0457	0458	0459	0460	0461	0462	0463
1D_	0464	0465	0466	0467	0468	0469	0470	0471	0472	0473	0474	0475	0476	0477	0478	0479
1E_	0480	0481	0482	0483	0484	0485	0486	0487	0488	0489	0490	0491	0492	0493	0494	0495
1F_	0496	0497	0498	0499	0500	0501	0502	0503	0504	0505	0506	0507	0508	0509	0510	0511

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
20_	0512	0513	0514	0515	0516	0517	0518	0519	0520	0521	0522	0523	0524	0525	0526	0527
21_	0528	0529	0530	0531	0532	0533	0534	0535	0536	0537	0538	0539	0540	0541	0542	0543
22_	0544	0545	0546	0547	0548	0549	0550	0551	0552	0553	0554	0555	0556	0557	0558	0559
23_	0560	0561	0562	0563	0564	0565	0566	0567	0568	0569	0570	0571	0572	0573	0574	0575
24_	0576	0577	0578	0579	0580	0581	0582	0583	0584	0585	0586	0587	0588	0589	0590	0591
25_	0592	0593	0594	0595	0596	0597	0598	0599	0600	0601	0602	0603	0604	0605	0606	0607
26_	0608	0609	0610	0611	0612	0613	0614	0615	0616	0617	0618	0619	0620	0621	0622	0623
27_	0624	0625	0626	0627	0628	0629	0630	0631	0632	0633	0634	0635	0636	0637	0638	0639
28_	0640	0641	0642	0643	0644	0645	0646	0647	0648	0649	0650	0651	0652	0653	0654	0655
29_	0656	0657	0658	0659	0660	0661	0662	0663	0664	0665	0666	0667	0668	0669	0670	0671
2A_	0672	0673	0674	0675	0676	0677	0678	0679	0680	0681	0682	0683	0684	0685	0686	0687
2B_	0688	0689	0690	0691	0692	0693	0694	0695	0696	0697	0698	0699	0700	0701	0702	0703
2C_	0704	0705	0706	0707	0708	0709	0710	0711	0712	0713	0714	0715	0716	0717	0718	0719
2D_	0720	0721	0722	0723	0724	0725	0726	0727	0728	0729	0730	0731	0732	0733	0734	0735
2E_	0736	0737	0738	0739	0740	0741	0742	0743	0744	0745	0746	0747	0748	0749	0750	0751
2F_	0752	0753	0754	0755	0756	0757	0758	0759	0760	0761	0762	0763	0764	0765	0766	0767
30_	0768	0769	0770	0771	0772	0773	0774	0775	0776	0777	0778	0779	0780	0781	0782	0783
31_	0784	0785	0786	0787	0788	0789	0790	0791	0792	0793	0794	0795	0796	0797	0798	0799
32_	0800	0801	0802	0803	0804	0805	0806	0807	0808	0809	0810	0811	0812	0813	0814	0815
33_	0816	0817	0818	0819	0820	0821	0822	0823	0824	0825	0826	0827	0828	0829	0830	0831
34_	0832	0833	0834	0835	0836	0837	0838	0839	0840	0841	0842	0843	0844	0845	0846	0847
35_	0848	0849	0850	0851	0852	0853	0854	0855	0856	0857	0858	0859	0860	0861	0862	0863
36_	0864	0865	0866	0867	0868	0869	0870	0871	0872	0873	0874	0875	0876	0877	0878	0879
37_	0880	0881	0882	0883	0884	0885	0886	0887	0888	0889	0890	0891	0892	0893	0894	0895
38_	0896	0897	0898	0899	0900	0901	0902	0903	0904	0905	0906	0907	0908	0909	0910	0911
39_	0912	0913	0914	0915	0916	0917	0918	0919	0920	0921	0922	0923	0924	0925	0926	0927
3A_	0928	0929	0930	0931	0932	0933	0934	0935	0936	0937	0938	0939	0940	0941	0942	0943
3B_	0944	0945	0946	0947	0948	0949	0950	0951	0952	0953	0954	0955	0956	0957	0958	0959
3C_	0960	0961	0962	0963	0964	0965	0966	0967	0968	0969	0970	0971	0972	0973	0974	0975
3D_	0976	0977	0978	0979	0980	0981	0982	0983	0984	0985	0986	0987	0988	0989	0990	0991
3E_	0992	0993	0994	0995	0996	0997	0998	0999	1000	1001	1002	1003	1004	1005	1006	1007
3F_	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
40_	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039
41_	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055
42_	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071
43_	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087
44_	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103
45_	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119
46_	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135
47_	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151
48_	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167
49_	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183
4A_	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199
4B_	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215
4C_	1216	1217	1218	1219	1220	1221	1222	1223	1224	1225	1226	1227	1228	1229	1230	1231
4D_	1232	1233	1234	1235	1236	1237	1238	1239	1240	1241	1242	1243	1244	1245	1246	1247
4E_	1248	1249	1250	1251	1252	1253	1254	1255	1256	1257	1258	1259	1260	1261	1262	1263
4F_	1264	1265	1266	1267	1268	1269	1270	1271	1272	1273	1274	1275	1276	1277	1278	1279
50_	1280	1281	1282	1283	1284	1285	1286	1287	1288	1289	1290	1291	1292	1293	1294	1295
51_	1296	1297	1298	1299	1300	1301	1302	1303	1304	1305	1306	1307	1308	1309	1310	1311
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5B_	1456	1457	1458	1459	1460	1461	1462	1463	1464	1465	1466	1467	1468	1469	1470	1471
5C_	1472	1473	1474	1475	1476	1477	1478	1479	1480	1481	1482	1483	1484	1485	1486	1487
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6A_	1696	1697	1698	1699	1700	1701	1702	1703	1704	1705	1706	1707	1708	1709	1710	1711
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6F_	1776	1777	1778	1779	1780	1781	1782	1783	1784	1785	1786	1787	1788	1789	1790	1791
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77_	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
78_	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935
79_	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
7A_	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
7B_	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
7C_	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
7D_	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
7E_	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
7F_	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047

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81_	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079
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84_	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127
85_	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143
86_	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159
87_	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175
88_	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191
89_	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207
8A_	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223
8B_	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239
8C_	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255
8D_	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271
8E_	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287
8F_	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303
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9A_	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479
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9E_	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543
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A1_	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591
A2_	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607
A3_	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623
A4_	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639
A5_	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655
A6_	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671
A7_	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687
A8_	2688	2689	2690	2691	2692	2693	2694	2695	2696	2697	2698	2699	2700	2701	2702	2703
A9_	2704	2705	2706	2707	2708	2709	2710	2711	2712	2713	2714	2715	2716	2717	2718	2719
AA_	2720	2721	2722	2723	2724	2725	2726	2727	2728	2729	2730	2731	2732	2733	2734	2735
AB_	2736	2737	2738	2739	2740	2741	2742	2743	2744	2745	2746	2747	2748	2749	2750	2751
AC_	2752	2753	2754	2755	2756	2757	2758	2759	2760	2761	2762	2763	2764	2765	2766	2767
AD_	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783
AE_	2784	2785	2786	2787	2788	2789	2790	2791	2792	2793	2794	2795	2796	2797	2798	2799
AF_	2800	2801	2802	2803	2804	2805	2806	2807	2808	2809	2810	2811	2812	2813	2814	2815
B0_	2816	2817	2818	2819	2820	2821	2822	2823	2824	2825	2826	2827	2828	2829	2830	2831
B1_	2832	2833	2834	2835	2836	2837	2838	2839	2840	2841	2842	2843	2844	2845	2846	2847
B2_	2848	2849	2850	2851	2852	2853	2854	2855	2856	2857	2858	2859	2860	2861	2862	2863
B3_	2864	2865	2866	2867	2868	2869	2870	2871	2872	2873	2874	2875	2876	2877	2878	2879
B4_	2880	2881	2882	2883	2884	2885	2886	2887	2888	2889	2890	2891	2892	2893	2894	2895
B5_	2896	2897	2898	2899	2900	2901	2902	2903	2904	2905	2906	2907	2908	2909	2910	2911
B6_	2912	2913	2914	2915	2916	2917	2918	2919	2920	2921	2922	2923	2924	2925	2926	2927
B7_	2928	2929	2930	2931	2932	2933	2934	2935	2936	2937	2938	2939	2940	2941	2942	2943
B8_	2944	2945	2946	2947	2948	2949	2950	2951	2952	2953	2954	2955	2956	2957	2958	2959
B9_	2960	2961	2962	2963	2964	2965	2966	2967	2968	2969	2970	2971	2972	2973	2974	2975
BA_	2976	2977	2978	2979	2980	2981	2982	2983	2984	2985	2986	2987	2988	2989	2990	2991
BB_	2992	2993	2994	2995	2996	2997	2998	2999	3000	3001	3002	3003	3004	3005	3006	3007
BC_	3008	3009	3010	3011	3012	3013	3014	3015	3016	3017	3018	3019	3020	3021	3022	3023
BD_	3024	3025	3026	3027	3028	3029	3030	3031	3032	3033	3034	3035	3036	3037	3038	3039
BE_	3040	3041	3042	3043	3044	3045	3046	3047	3048	3049	3050	3051	3052	3053	3054	3055
BF_	3056	3057	3058	3059	3060	3061	3062	3063	3064	3065	3066	3067	3068	3069	3070	3071

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C0_	3072	3073	3074	3075	3076	3077	3078	3079	3080	3081	3082	3083	3084	3085	3086	3087
C1_	3088	3089	3090	3091	3092	3093	3094	3095	3096	3097	3098	3099	3100	3101	3102	3103
C2_	3104	3105	3106	3107	3108	3109	3110	3111	3112	3113	3114	3115	3116	3117	3118	3119
C3_	3120	3121	3122	3123	3124	3125	3126	3127	3128	3129	3130	3131	3132	3133	3134	3135
C4_	3136	3137	3138	3139	3140	3141	3142	3143	3144	3145	3146	3147	3148	3149	3150	3151
C5_	3152	3153	3154	3155	3156	3157	3158	3159	3160	3161	3162	3163	3164	3165	3166	3167
C6_	3168	3169	3170	3171	3172	3173	3174	3175	3176	3177	3178	3179	3180	3181	3182	3183
C7_	3184	3185	3186	3187	3188	3189	3190	3191	3192	3193	3194	3195	3196	3197	3198	3199
C8_	3200	3201	3202	3203	3204	3205	3206	3207	3208	3209	3210	3211	3212	3213	3214	3215
C9_	3216	3217	3218	3219	3220	3221	3222	3223	3224	3225	3226	3227	3228	3229	3230	3231
CA_	3232	3233	3234	3235	3236	3237	3238	3239	3240	3241	3242	3243	3244	3245	3246	3247
CB_	3248	3249	3250	3251	3252	3253	3254	3255	3256	3257	3258	3259	3260	3261	3262	3263
CC_	3264	3265	3266	3267	3268	3269	3270	3271	3272	3273	3274	3275	3276	3277	3278	3279
CD_	3280	3281	3282	3283	3284	3285	3286	3287	3288	3289	3290	3291	3292	3293	3294	3295
CE_	3296	3297	3298	3299	3300	3301	3302	3303	3304	3305	3306	3307	3308	3309	3310	3311
CF_	3312	3313	3314	3315	3316	3317	3318	3319	3320	3321	3322	3323	3324	3325	3326	3327
D0_	3328	3329	3330	3331	3332	3333	3334	3335	3336	3337	3338	3339	3340	3341	3342	3343
D1_	3344	3345	3346	3347	3348	3349	3350	3351	3352	3353	3354	3355	3356	3357	3358	3359
D2_	3360	3361	3362	3363	3364	3365	3366	3367	3368	3369	3370	3371	3372	3373	3374	3375
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D4_	3392	3393	3394	3395	3396	3397	3398	3399	3400	3401	3402	3403	3404	3405	3406	3407
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D6_	3424	3425	3426	3427	3428	3429	3430	3431	3432	3433	3434	3435	3436	3437	3438	3439
D7_	3440	3441	3442	3443	3444	3445	3446	3447	3448	3449	3450	3451	3452	3453	3454	3455
D8_	3456	3457	3458	3459	3460	3461	3462	3463	3464	3465	3466	3467	3468	3469	3470	3471
D9_	3472	3473	3474	3475	3476	3477	3478	3479	3480	3481	3482	3483	3484	3485	3486	3487
DA_	3488	3489	3490	3491	3492	3493	3494	3495	3496	3497	3498	3499	3500	3501	3502	3503
DB_	3504	3505	3506	3507	3508	3509	3510	3511	3512	3513	3514	3515	3516	3517	3518	3519
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DD_	3536	3537	3538	3539	3540	3541	3542	3543	3544	3545	3546	3547	3548	3549	3550	3551
DE_	3552	3553	3554	3555	3556	3557	3558	3559	3560	3561	3562	3563	3564	3565	3566	3567
DF_	3568	3569	3570	3571	3572	3573	3574	3575	3576	3577	3578	3579	3580	3581	3582	3583

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E1_	3600	3601	3602	3603	3604	3605	3606	3607	3608	3609	3610	3611	3612	3613	3614	3615
E2_	3616	3617	3618	3619	3620	3621	3622	3623	3624	3625	3626	3627	3628	3629	3630	3631
E3_	3632	3633	3634	3635	3636	3637	3638	3639	3640	3641	3642	3643	3644	3645	3646	3647
E4_	3648	3649	3650	3651	3652	3653	3654	3655	3656	3657	3658	3659	3660	3661	3662	3663
E5_	3664	3665	3666	3667	3668	3669	3670	3671	3672	3673	3674	3675	3676	3677	3678	3679
E6_	3680	3681	3682	3683	3684	3685	3686	3687	3688	3689	3690	3691	3692	3693	3694	3695
E7_	3696	3697	3698	3699	3700	3701	3702	3703	3704	3705	3706	3707	3708	3709	3710	3711
E8_	3712	3713	3714	3715	3716	3717	3718	3719	3720	3721	3722	3723	3724	3725	3726	3727
E9_	3728	3729	3730	3731	3732	3733	3734	3735	3736	3737	3738	3739	3740	3741	3742	3743
EA_	3744	3745	3746	3747	3748	3749	3750	3751	3752	3753	3754	3755	3756	3757	3758	3759
EB_	3760	3761	3762	3763	3764	3765	3766	3767	3768	3769	3770	3771	3772	3773	3774	3775
EC_	3776	3777	3778	3779	3780	3781	3782	3783	3784	3785	3786	3787	3788	3789	3790	3791
ED_	3792	3793	3794	3795	3796	3797	3798	3799	3800	3801	3802	3803	3804	3805	3806	3807
EE_	3808	3809	3810	3811	3812	3813	3814	3815	3816	3817	3818	3819	3820	3821	3822	3823
EF_	3824	3825	3826	3827	3828	3829	3830	3831	3832	3833	3834	3835	3836	3837	3838	3839
F0_	3840	3841	3842	3843	3844	3845	3846	3847	3848	3849	3850	3851	3852	3853	3854	3855
F1_	3856	3857	3858	3859	3860	3861	3862	3863	3864	3865	3866	3867	3868	3869	3870	3871
F2_	3872	3873	3874	3875	3876	3877	3878	3879	3880	3881	3882	3883	3884	3885	3886	3887
F3_	3888	3889	3890	3891	3892	3893	3894	3895	3896	3897	3898	3899	3900	3901	3902	3903
F4_	3904	3905	3906	3907	3908	3909	3910	3911	3912	3913	3914	3915	3916	3917	3918	3919
F5_	3920	3921	3922	3923	3924	3925	3926	3927	3928	3929	3930	3931	3932	3933	3934	3935
F6_	3936	3937	3938	3939	3940	3941	3942	3943	3944	3945	3946	3947	3948	3949	3950	3951
F7_	3952	3953	3954	3955	3956	3957	3958	3959	3960	3961	3962	3963	3964	3965	3966	3967
F8_	3968	3969	3970	3971	3972	3973	3974	3975	3976	3977	3978	3979	3980	3981	3982	3983
F9_	3984	3985	3986	3987	3988	3989	3990	3991	3992	3993	3994	3995	3996	3997	3998	3999
FA_	4000	4001	4002	4003	4004	4005	4006	4007	4008	4009	4010	4011	4012	4013	4014	4015
FB_	4016	4017	4018	4019	4020	4021	4022	4023	4024	4025	4026	4027	4028	4029	4030	4031
FC_	4032	4033	4034	4035	4036	4037	4038	4039	4040	4041	4042	4043	4044	4045	4046	4047
FD_	4048	4049	4050	4051	4052	4053	4054	4055	4056	4057	4058	4059	4060	4061	4062	4063
FE_	4064	4065	4066	4067	4068	4069	4070	4071	4072	4073	4074	4075	4076	4077	4078	4079
FF_	4080	4081	4082	4083	4084	4085	4086	4087	4088	4089	4090	4091	4092	4093	4094	4095

TAPE EDITOR PROGRAM

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1. INTRODUCTION

The Tape Editor System (TED) is a MICRO 810 program for manipulating and generating paper tapes suitable for input to the MICRO 810 Assembler (MAP810). The program is controlled by a teletype and the teletype's paper tape reader and paper tape punch are normally used as the input and output mediums. Optionally a card reader or high-speed paper tape reader and/or punch may also be used.

The following is a list of features available to the user:

- Read and number source statements from a paper tape or cards into a buffer memory.

- Print multiple or single statements.

- Assign new numbers to statements.

- Delete one or more statements from the buffer.

- Insert or replace single statements in the buffer.

- Edit statements by character.

- Skip a specified number of source statements from the input medium.

- Write one or more source statements from the buffer with multiple spaces compressed.

2. OPERATING INSTRUCTIONS

Loading the editor by the bootstrap and basic loaders

1. Place the TTY in the off-line mode; place the reader control lever to the "free" position and enable the teletype reader. Type control and Q.
2. Place the TTY in the on-line mode and insert the program tape in the reader with the first rub-out character at the read station. Set the reader control lever in the stop (center) position.
3. Set the front panel sense switches as follows:
 - Sense switch 1: must be off
on for parallel TTY interface.
 - Sense switch 2: must be off.
 - Sense switch 3: must be off.
 - Sense switch 4: must be on. This selects the bootstrap loader whenever the run switch is selected and was preceded by a reset.
4. Press the reset and the run switches and the system will wait for the teletype reader to be started.
5. Press the TTY reader lever to the start position.

When the basic loader is loaded and operating properly, the teletype page printer mechanism will chatter whenever a record separator passes the read station. This is caused by the issuance of reader off and a reader on codes between records.

If a checksum error is found, the message "CE" is typed and the system will halt. Another attempt to properly load the record may be accomplished by backing up the tape to the previous record separator (indicated by 3 successive rub-outs), placing the reader control lever in the stop (center) position, and pressing the run switch on the front console. When the tape is properly loaded, the reader will be stopped and control will transfer to the loaded program.

If another input device is available on the system, it may be used to load the program. The basic loader for that device is supplied as a separate paper tape and is read through the teletype reader by the previously described procedure. Following the loading of this short tape, the program will be automatically loaded via the other device.

Loading the editor by the R operator of TOS

Unroll about 30 inches of the program tape to bypass the basic loader and locate the leader (any frame with channel 8 present) of the formatted tape. Insert the tape into the reader with any part of the leader at the read station and set the reader control lever to center position. Typing an R will start the loading. A checksum is calculated for each record loaded and if it doesn't equal the checksum read with the record, the letters "CE" will be typed and control will return to TOS. By backing up the tape to the previous separator and typing an R, another attempt may be made to load the tape.

TED Operators

All operations which are performed by TED are initiated by typing a single alphabetic character which designates one of twelve operators. These operators are described in detail in Section 3.

The TED program is ready to accept an operator designator any time after the ringing of the teletype bell and typing of a dash. If anything other than a legal operator designator is typed, TED will reject the character and again ring the bell.

If a line feed is typed, TED will print the next statement found in the buffer following the statement number of the last operation performed. In this manner, it is possible to step through and print a sequence of statements without typing a P and statement number.

Statement Numbers

All statements which are entered into the buffer are assigned a three digit decimal number in the range of 000 to 999. These numbers are used as parameters for the operators. When typing statement numbers as part of an operator specification, leading 0's may be omitted. If more than the three decimal digits are entered, TED will take the last three digits. When entering statement numbers, no spaces or other than decimal digits may be entered. TED assumes that the decimal number is terminated when it receives the first non-decimal character and therefore does not act upon the input until the digit string is terminated. If the first non-decimal character is not a space, comma, or carriage return, the operator request is terminated and TED will ring the bell to request a new operator. When more than one statement number or other decimal value is typed, the items may be separated by either a comma or a space. For clarity in this document, only comma's are shown.

If the third and/or fourth parameter of an operator is not supplied, the program supplies values of one. If the second parameter is not supplied, it is assumed to be equal to the first parameter; therefore the operation is on a single statement. If the first parameter is not supplied, the program takes the next statement number as determined by the previous operation.

When using an ASR 33 teletype, insure that the punch mechanism has not been left enabled due to a previous depression of the "lock on" button located on the punching unit. This will mechanically inhibit the function of punch on and punch off codes and result in the punching of 8 level tapes whenever the unit is printing. To correct this, place the power switch in the off-line (local) mode, depress the "unlock" button on the punching unit, type control and T, and return the teletype to the on-line mode.

3. OPERATORS

ASSIGN: A m, n

The A operator causes the statement numbered m to be assigned the new number n. Both parameters m and n must be present or no operation occurs. Parameter n must not be the number of an existing statement in the buffer.

DELETE: D m, n

The D operator causes the single statement numbered m, or all the statements in the range of m to n inclusive, to be deleted from the buffer. The space in the buffer occupied by these statements is eliminated by moving statements into the area of the deleted statements.

EDIT: E m

The E operator allows for editing of statement numbered m. If statement m is not in the buffer, this operator performs no operation. The operator allows input from the keyboard to replace characters from the existing statement on a character by character basis. Certain control characters allow for scanning the existing statement and aborting the edit. In the process of carrying out this operator, a new statement is placed in the buffer if properly terminated by a carriage return; the original statement numbered m is removed from the buffer.

After terminating the statement number, and after a copy up to a designated character, any keyboard entry will replace characters of the original statement. The control characters listed below are recognized and perform the stated functions.

- Carriage return — Terminates the editing operation and causes the edited statement to be entered into buffer.
- Control Z — All the characters up to and including the first occurrence of the character entered after Control Z.
- Control D — Copies the rest of the original statement, terminates the editing operation, and causes the edited statement to be entered into the buffer.
- ESC — Aborts the edit and leaves the statement unmodified.

When the card reader is the input device, a conversion is made from Hollerith to ASCII codes and only 72 columns of the card are read and placed in the buffer. Trailing blank columns are deleted from the buffer. If an input error occurs in the card reader or the hopper is empty, the read operator is terminated and an error message with the next statement number is typed.

SKIP: S k

The S operator causes k statements to be skipped from the input device. If sense switch one is on, the card reader is the input device.

TYPE STATEMENTS: T m, n, k

The T operator allows statements to be typed from the keyboard with each statement being assigned a statement number starting with m and incremented by k until a statement number greater than n is reached. The program types the statement number and the operator then enters the statement terminated by a carriage return. Typing ESC causes the operator to be aborted. Any other control code causes the current statement to be aborted.

WRITE: W m, n

The W operator causes the single statement numbered m or all the statements in the range of m to n inclusive to be punched on the selected paper tape punch. Each statement is punched with a carriage return, line feed, and two rub-out characters at the end of the statement. All sequences of one or more spaces are converted to non-printing control characters to provide some compression of the length of tape. This compressed tape is acceptable to the MAP810 Assembler.

ZERO BUFFER: Z

The Z operator causes all statements to be deleted from the buffer and resets the next available buffer location to the beginning of the buffer.

INSERT: I m

The I operator causes a statement numbered m to be entered into the buffer. If a statement numbered m already exists in the buffer it is replaced by the new statement. The new statement is entered via the keyboard immediately after terminating the statement number. The entered statement is terminated by a carriage return which also terminates the I operator.

LEADER/TRAILER: L

The L operator causes the paper tape punching device to punch 6 inches of blank tape.

NUMBER: N m, n, s, k

The N operator causes the single statement numbered m, or all the statements in the range of m to n inclusive, to be renumbered starting with statement number s and at intervals of k. No statements are entered into the buffer or moved within the buffer by this operator. If the parameter s is not provided, the re-numbering starts with statement number one. Omission of k will cause the interval to be one. New statement numbers may be the same as numbers in the range m to n, but should not be identical to any other statement numbers currently in the buffer.

PRINT: P m, n

The statement numbered m or all the statements in the range of m to n inclusive are printed on the teletype along with the three digit statement number. If only a single statement is to be typed, it is typed on the same line as the P operator and the statement number; otherwise a carriage return and line feed takes place before the typing of the first statement number and statement.

READ: R n, n, k

The R operator causes one or more statements to be read from the designated paper tape reader or the card reader as determined by sense switch one. If sense switch one is on, the card reader becomes the input device. All statements which are read are assigned a number starting with m and incremented by k until a statement number greater than n is reached. If parameters n and k are not entered before the last statement is read by the operator, the tape will stop and the reader will be turned off. At this time, another tape may be placed in the reader and it may be restarted by pressing the control lever to the start position; or the read operator may be terminated by typing a control S (X-off) which will cause the next statement number to be typed.

APPENDIX A

SUMMARY OF TAPE EDITOR OPERATORS

Note: A carriage return is signified by (CR)

A m, n	Assign the number n to statement m.
D m, (CR)	Delete statement m.
D m, n	Delete statements in the range of m to n inclusive.
E m	Edit statement m.
I m	Insert (or replace) statement m.
L	Punch 6 inches of leader or trailer.
N m, n, s (CR)	Renumber statements in the range of m to n inclusive starting at S in steps of one.
N m, n, s, k	Renumber statements in the range of m to n inclusive starting at S in steps of k.
P m (CR)	Print statement m.
P m, n	Print statements in the range of m to n inclusive in order of ascending statement numbers.
R m	Read a single statement and assign it the number m.
R m, n (CR)	Read n-m +1 statements and assign numbers starting with m in steps of one.
R m, n, k	Read statements and assign numbers starting with m in steps of k until a statement number greater than n is reached.
S k	Skip k statements from the input device.
T m, n (CR)	Enter n-m +1 statements from the teletype and assign numbers starting with m in steps of one.
T m, n, k	Enter statements from the teletype and assign numbers starting with m in steps of k until a number greater than n is reached.
W m (CR)	Punch statement m on paper tape in compressed format.
W m, n	Punch statements in the range of m to n inclusive on paper tape in compressed format.
Z	Zero the buffer.

TELETYPE OPERATING SYSTEM (TOS)

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1. INTRODUCTION

The Teletype Operating System (TOS) is an on-line executive system incorporating teletype control of debug, console and executive functions. The teletype is used rather than any console operations except for the console interrupt, which is used to cause the computer to return to TOS while executing another program.

The following is a list of the features available to the user:

- Display the contents of a memory cell.

- Modify the contents of a memory cell.

- Two breakpoints for program debugging.

- Display the content of a specified memory area.

- Punch the content of a specified memory area into paper tape.

- Display the content of operational registers.

- Modify the content of operational registers.

- Execute user program.

- Load a formatted program tape.

- Hexadecimal arithmetic

2. INSTRUCTIONS FOR USE

This section provides instructions for using the TOS program.

Loading the TOS

The TOS is loaded into memory via the basic paper tape loader. This basic loader is in the bootstrap format (1 data byte per frame of tape) and is spliced onto the front of the TOS tape. The splice is made so that the last frame of the loader is followed immediately with the leader of the TOS tape. The microprogrammed bootstrap loader loads the basic loader and transfers control to it. Then the basic loader loads the TOS and, after a successful load, transfers control to the TOS. Following is a procedure for loading a formatted paper tape through the teletype via the bootstrap and basic loaders.

1. Place the TTY in the off-line mode, place the reader control lever to the "free" position and enable the teletype reader. Type control and Q.
2. Place the TTY in the on-line mode and insert the TOS tape in the reader with the first rub-out character at the read station. Set the reader control lever in the stop (center) position.
3. Set the front panel sense switches as follows:

Sense switch 1:	off for serial TTY interface, on for parallel TTY interface.
Sense switch 2:	must be off.
Sense switch 3:	must be off.
Sense switch 4:	must be on. This selects the bootstrap loader whenever the run switch is selected and was preceded by a reset.
4. Press the reset and the run switches and the system will wait for the teletype reader to be started.
5. Press the TTY reader lever to the start position.

When the basic loader is loaded and operating properly, the teletype page printer mechanism will chatter whenever a record separator passes the read station. This is caused by the issuance of reader off and reader on codes between records.

If a checksum error is found, the message 'CE' is typed and the system will halt. Another attempt to properly load the record may be accomplished by backing up the tape to the previous record separator, placing the reader control lever in the stop (center) position, and pressing the run switch on the front console. When the TOS is properly loaded, control will transfer to it, and the teletype bell will ring.

TOS Operators

All operations which are performed by TOS are initiated by typing a single alphabetic character which designates one of 14 operators. These operators are described in detail in Section 3 and are summarized in Appendix A.

The TOS program is ready to accept an operator designator character at any time after ringing the bell. If anything other than a legal operator designator is typed TOS will reject the character and ring the bell again.

NOTE: For the purposes of this manual, all references to the teletype carriage return are shown as; $\text{\textcircled{CR}}$.

Hexadecimal Input/Output

All data and addresses are displayed and entered in hexadecimal. The 16 hexadecimal digits are: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E and F. The hexadecimal values may not be signed. When entering a two digit memory cell value or a four digit memory address, no spaces or other than hexadecimal characters may be in the digit string. TOS assumes that the hexadecimal digit string is terminated when it receives the first non-hexadecimal character. Therefore, it will not act on an input until the digit string is terminated. If more than the required number of digits are entered, TOS will take the last two or four as required. Leading zero digits need not be typed. If the first non-hexadecimal character is not a space, comma, or carriage return (CR), the data or address value is ignored and the operation is terminated. However, before termination, all valid hexadecimal data or address values that were accepted are retained. When more than one address or data value is typed they may be separated by either a comma or a space. For clarity in this document only commas are shown. When an operator requires an address, it will ignore leading spaces, i.e.,:

D ssss, eeee $\text{\textcircled{CR}}$

Console Storage Area

A storage area is reserved as part of TOS for saving the operational registers of a user program when the computer is executing TOS. The operational registers, the word length control, and the overflow flag of the computer are stored in this area when a trap or console interrupt is executed. The contents of these registers may be modified and displayed by the appropriate operators. The console storage area is loaded into the operational registers by the G operator. If an address is supplied with the G operator then this address is placed in the storage area for the P register before the registers are restored.

Console Interrupt

The console interrupt is used to interrupt a running program or to start the computer and bring control to TOS so that teletype control can be exercised. The operational registers and word length and overflow are stored in the console storage area and an asterisk, followed by the contents of the P register at the time of interrupt, is typed out in the same manner as the P operator. Other registers can also be displayed by typing a space or comma after each register is displayed. The console interrupt address at location 80_{16} is initialized when TOS is loaded.

3. OPERATORS

READ: R

The R operator causes TOS to load a program tape. This operation can be configured for any standard input devices, but normally the device will be the teletype paper tape reader. The tape must be inserted in the reader with the leader (any frame with channel 8 present) place at the read station before the R is typed. When the loader encounters a record with a zero byte count the loading process is terminated and control is transferred to TOS or to the transfer address. If there is no zero byte count record, loading will continue until the computer is halted or until the console interrupt is activated. A checksum is calculated for each record loaded and if it doesn't equal the checksum read with the record, the letters 'CE' will be typed and control will return to TOS. By backing up the tape to the previous separator and typing an R, another attempt may be made to load the tape.

WRITE: W ssss, eeee (CR)

The W operation causes the contents of the memory area starting with ssss and ending with eeee to be written on the standard output device, normally the teletype punch. Each record of the output will contain 128_{10} data bytes except the last record which will contain a number of bytes equal to the total byte count modulo 128_{10} . Typing a CR following the second address will start the operation.

HEXADECIMAL: H tttt, uuuu,

The H operation causes the hexadecimal sum of tttt and uuuu and the hexadecimal difference of tttt minus uuuu to be displayed. The uuuu entry is terminated by a space or comma and TOS will type the four digit sum followed by the difference.

ENTER REGISTER: P A B X O

When the letter P,A,B,X or O is typed, TOS will return with the hexadecimal contents of the corresponding register followed by a dash. At this time the contents of the register can be changed by typing in the new value. If a space or a comma is typed, the next register in the sequence is displayed. If a CR is typed or if a space or comma is typed after the contents of the O register has been displayed, this operator is terminated. The O register is typed as a full 16 bit register but only the low order 3 bits are used by TOS when presetting the operational registers during a Go-To operation. Bits 0 and 1 indicates the operand word length (0 = 1 Byte) and Bit 2 contains the overflow status.

DUMP: D ssss, eeee (CR)

The D operation causes the contents of memory to be dumped on the teletype printer starting with the address ssss and ending with eeee. TOS types the four digit address at the left margin followed by 16 bytes of memory. A single space is provided between every byte

except that there is a double space after every fourth byte. This operator is terminated when the contents of the last memory cell has been typed, or the console interrupt is activated. Typing a CR following the second address will start the operation.

MEMORY: M ssss

The M operator causes the contents of the memory location specified by ssss to be typed out followed by a dash. At this time the contents of the memory location may be changed by typing in two hexadecimal digits. When a space or a comma is typed after the data or after the dash, the contents of the next memory location is typed by TOS. A CR terminates this operator.

GO TO: G ssss, tttt, uuuu (CR)

The G operation causes TOS to set trap instructions at memory locations tttt and uuuu, to load the console storage area into the A,B,X and OV/W registers, and to transfer control to location ssss. If a CR is typed after G all the registers including P are loaded from the console storage area so that control is transferred to the location where program execution stopped due to the last trap or console interrupt. If a CR is typed after ssss, no traps are set, and if a CR is typed after tttt only one trap is set. All traps that are set are automatically cleared when either one is executed or control is transferred to TOS, signalled by the ringing of the teletype bell. The instruction at the trap location is restored in memory but has not yet been executed. Upon return from a trap all operational registers are stored in the console storage area and an asterisk, followed by the contents of the P register, is typed out in the same manner as the P operator. A trap at location zero is not permitted as this value is used by TOS to indicate that a trap has not been set.

STORE: S ssss, vv, vv, vv

The S operation causes the hexadecimal digits, vv, to be stored in consecutive memory locations starting at address ssss. This operator is terminated when a CR is typed. Leading zeros need not be typed and a void value (comma or space followed by a comma or space) will cause a zero byte to be stored.

LEADER/TRAILER: L

The L operator will cause the paper tape punching device to punch six inches of tape containing channel eight punches only.

EXECUTION RECORD: E ssss (CR)

The E operation punches an end of tape record consisting of a zero record size and an execution address of ssss. If the ssss is omitted, a zero value will be punched as an execution address. Following the punching of this record, six inches of trailer will be punched automatically. Typing a CR will start the operation.

4. PROGRAM TAPE FORMAT

The binary paper tape format, see Figure 1, can be generated by the two pass assembler, and by the write subroutine of TOS. This format allows for variable length data records of up to 128_{10} eighth bit bytes, a record load address, and a record checksum. Each record contains a count of the number of data bytes, and the 15 bit address at which data is to be loaded. The data is loaded sequentially starting with this address. When there is a discontinuity in the loading addresses a new record is started so that a load address may be specified. The last byte of each record is a checksum which is the summation of the byte count, load address, and data bytes formed on an eight bit basis with overflow added into the least significant bit of the sum.

A byte count of zero signifies a record of zero data bytes, and the 15 bit address is taken as a transfer address. This record is optional and if present will be the last record read. The TOS stops the paper tape reader and transfers control to the loaded program. If the transfer address is zero, control is returned to TOS.

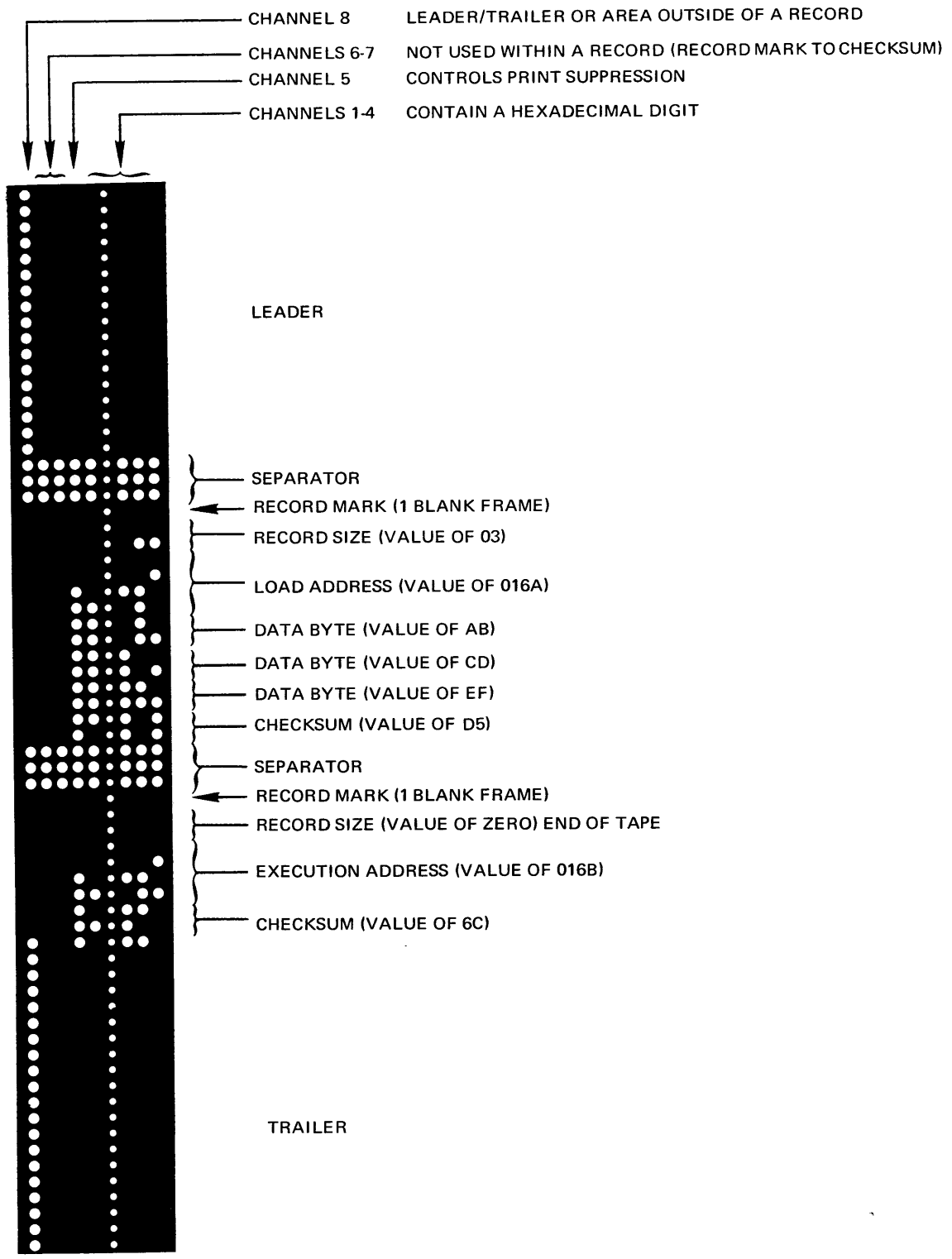


FIGURE 1. BINARY PAPER TAPE FORMAT

APPENDIX A

SUMMARY OF TOS OPERATORS

Underlined items are typed out by TOS:

P	<u>xxxx</u> -nnnn, <u>xxxx</u> -	(CR)	Display contents of the P register, change the contents to nnnn and display contents of the A register. Leave the A register unaltered and terminate the operation.
A	<u>xxxx</u> -nnnn	(CR)	Display contents of the A register, change the contents to nnnn and terminate the operation.
B	<u>xxxx</u> -	(CR)	Display contents of the B register, leave the B register unaltered and terminate the operation.
X	<u>xxxx</u> -, <u>xxxx</u> -	(CR)	Display contents of the X register, leave the X register unaltered and display contents of the OV/W register. Leave the OV/W register unaltered and terminate the operation.
O	<u>xxxx</u> -	(space, comma or (CR)	Display contents of the OV/W register, leave the OV/W register unaltered and terminate the operation.
G	(CR)		Control passes to address in P register.
G	ssss	(CR)	Control passes to location ssss.
G	ssss, tttt,	(CR)	Control passes to location ssss, a trap is set at location tttt.
G	ssss, tttt, uuuu	(CR)	Control passes to location ssss, traps are set at locations tttt and uuuu.
G,	tttt	(CR)	Control passes to address in P register, a trap is set at location tttt.
G,	tttt, uuuu	(CR)	Control passes to address in P register, traps are set at locations tttt and uuuu.
R			Read a formatted paper tape. Control will return to TOS if the execution address is equal to zero, otherwise, it passes to the location indicated by the address.
W	ssss, tttt	(CR)	Write the contents of memory from locations ssss through tttt into formatted paper tape.
L			Punch six inches of paper tape leader (Channel 8 only).

- E ssss (CR) Write an end of tape record into formatted paper tape with an execution address of ssss. If ssss is omitted, a zero address will be used.
- H tttt, uuuu, ssss dddd Display sum and difference of tttt and uuuu.
- D ssss, tttt (CR) Dump the contents of memory locations ssss through tttt onto the teletype page printer. Each line will contain an address and up to 16 bytes of hexadecimal values.
- M ssss, xx - nn, xx - (CR) Display the contents of memory location ssss and change the contents to nn. Display the contents of location ssss+1, leave the location unaltered and terminate the operation. This operation must be completed on one line of type.
- S ssss,nn,nn,nn (CR) Store hexadecimal values starting at memory location ssss and continue until a CR is received. A void value will be stored as a zero byte. This operation must be completed on one line of type.
-



COMMENT AND EVALUATION SHEET
MICRO 810 COMPUTER
Teletype Operating System (TOS)
MAP810 Assembly Program
Tape Editor Program

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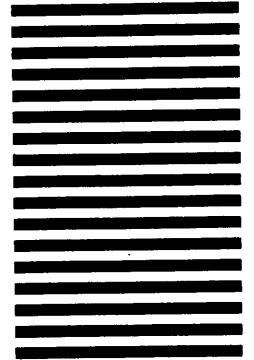
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