BYTE Reprint

Chapter 2

MACHINE LANGUAGE PROGRAMMING FOR THE "8008" and similar microcomputers

Reprinted from **MACHINE LANGUAGE PROGRAMMING FOR THE "8008" (and similar microcomputers).**

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INITIAL STEPS FOR DEVELOPING PROGRAMS

The first task that should be done prior to starting to write the individual instructions for a computer program is to decide exactly what it is that the computer is to perform and to write the goal(s) down on paper! This statement might seem unnecessary to some because it is such an obvious one. It is stated because the majority of people learning to develop programs will realize its significance when they discover, halfway through the writing of a large machine language program, that they left out a vital step. Such an error can typically result in the programmer having to start back at the beginning and rewrite the entire program. The practice of writing down just what tasks a particular program is to perform and the steps in which they are to be done, will save a lot of work in the long run. The written description should be as complete and detailed as necessary to ensure that exactly each step of the program will be clear when actually writing the program in machine language. It is generally wise for the novice programmer to take pains to be quite detailed in the initial description.

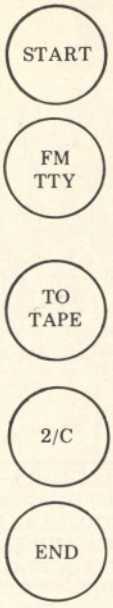
The act of actually writing down the proposed operation of the program desired serves several valuable purposes. First, it forces one to carefully review what is planned. In doing so, it often vividly reveals flaws in original mental ideas. Secondly, it serves as a guide and a check list as the machine language program is developed. Remember, it will often take a number of hours to write a fair sized program. These hours might be spread over several days or weeks. In this period of time the human mind can easily forget original intentions and plans if the human memory is not refreshed by written notes. A program that is not kept carefully organized as it is developed can become a real mess. This is especially so if one keeps forgetting key concepts or has to constantly add in forgotten routines. The time wasted by such sloppy procedures can be avoided if proper work habits are developed from the beginning.

Once one has written a description of the general task(s) to be performed, and has ascertained that there are no flaws to the overall concepts or ideas, it is a good idea to draw up a set of FLOW CHARTS for the proposed program. FLOW CHARTS are detailed written and symbolic descriptive diagrams of the flow of operations that are to occur as the program is executed. They also show the interrelationships between different portions of a program.

Over the years a variety of symbols and methods have been developed for creating flow charts. All of the varieties have the same basic purpose and most of the differences are the result of individuals pushing their own preferences. Most people can do admirably well using just a few basic symbols to denote fundamental types of operations in a computer program. The small group to be presented here will enable most microcomputer programmers to develop flow charts rapidly, with little confusion, and without having to learn a host of special symbols.

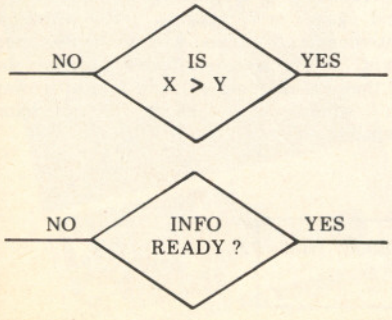
A CIRCLE may be used as a general purpose symbol to specify an entry or exit point in a routine or subroutine. Information may be printed inside the circle. This information might denote where the routine is coming from or going to (such as the page number and location on a page for a program that requires several sheets of paper to be flow charted). It might contain transfer

information. Or, it could denote the starting and stopping points within a program. Some typical examples of the CIRCLE symbol are illustrated next.



A square or rectangel may be used to denote a general or specific operation. The type of operation may be described inside the box such as illustrated in the following examples.

A diamond form may be used to symbolize a decision or branching point in a program. The determining factor(s) for the decision or branching operation may be indicated inside the symbol. The two side points of the diamond are used to illustrate the path taken when a decision has been made. The diamond symbol is illustrated next.

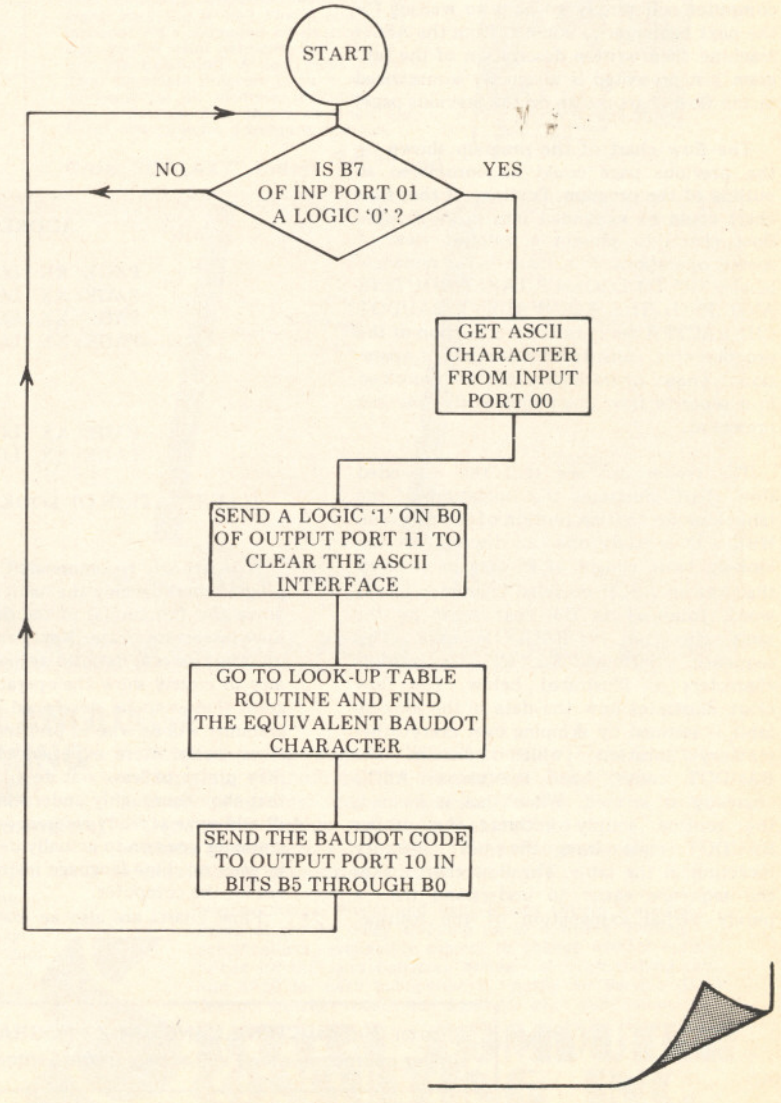


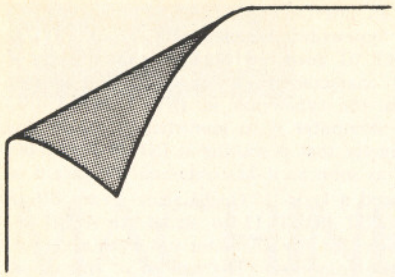
Lines with arrows may be used to interconnect the three types of symbols presented. In this way, the symbols may be connected to form readily understood FLOW CHARTS of operations that are to occur in a program and to show how various operations relate to each other. Flow charts are extremely valuable references when developing programs as well as when one wants to update or expand a program and needs to quickly review the operation of the program of specific interest.

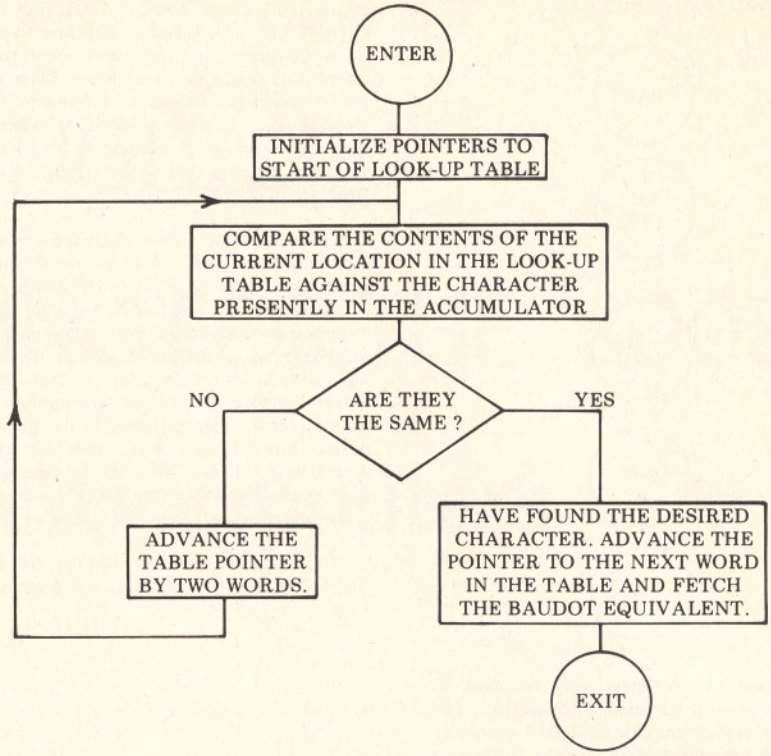
An example of a flow chart for a relatively simple program will be shown next. The program illustrated by the flow chart is to accept characters from an ASCII encoded electric typewriter and send out the equivalent character to a BAUDOT coded device. In this illustration it is assumed that the I/O interfaces to the machines are parallel interfaces (versus the possibility of being bit-serial interfaces). Thus, complex timing operations do not have to be discussed in the example. A written description of the example program could be stated as follows.

The computer is to monitor bit B7 of INPUT PORT 01, which is the control port for an interface to an ASCII encoded electric typewriter. Whenever bit B7 on INPUT PORT 01 goes low (logic '0') it indicates a new character is waiting in parallel format from the typewriter at INPUT PORT 00. The computer is to immediately obtain the character that is waiting at INPUT PORT 00 and as soon as it has obtained the data it is to send a logic '1' (high) signal to bit B0 of OUTPUT PORT 11 to signal the ASCII interface that the character has been accepted by the computer. (The receipt of this signal by the ASCII interface will then cause the ASCII interface to restore the control signal on bit B7 of INPUT PORT 01 to a high (logic '1') condition.)

Whenever a character has been received from the ASCII typewriter on INPUT PORT 00, the computer is to compare the character just received against an ASCII to BAUDOT look-up table which is stored in the computer's memory until it finds a match. It will then obtain the equivalent BAUDOT character from the conversion table. It will then send the BAUDOT code for the character in bit positions B5 through B0 of OUTPUT PORT 10. Bit B5 will serve to indicate to the BAUDOT interface whether







the code in bits B4 through B0 is to be processed by the BAUDOT device when it is in the LETTERS or FIGURES mode. It is assumed that the character rate (but not necessarily the baud rate) is the same for both machines so that the example may be simplified by eliminating the requirement for character buffering or stacking in the memory of the computer. However, in practical applications such capability might be required. The feature could be added to the program. However, for this case, as soon as the BAUDOT code has been transmitted (in parallel format) to the BAUDOT device, the computer will simply go back to waiting for the next character to come in from the ASCII machine. The written description of the program just presented is succinctly summarized in the flow chart shown on the previous page!

The flow chart of the program shown on the previous page could be considered an outline of the program. Portions of that flow chart could be expanded into more detailed flow charts to present a detailed view of special operations. For instance, the rectangle labeled GO TO LOOK-UP TABLE ROUTINE AND FIND THE EQUIVALENT BAUDOT CHARACTER really refers to a portion of the program that consists of a number of operations. Those operations could be described in a separate flow chart such as the one just presented.

The reader can see that the expanded flow chart illustrates the operation of the table look-up routine portion of the program. With a little study one can discern that the look-up table consist of an area in memory that has an ASCII encoded character in one word, followed in the next word by the same character in BAUDOT code. This sequence continues for all the possible characters as illustrated below. The flow chart illustrates how the data in the look-up table is scanned by skipping over every other memory location (which contains the BAUDOT codes) until the proper ASCII character is located. When that is located, the routine simply extracts the proper BAUDOT code from the next memory locaction in the table. The flow chart makes the sequence easier to understand than a purely verbal explanation of the routine.

ADDRESS	MEMORY CONTENTS
PAGE: XX LOC: Z	ASCII code for letter A
PAGE: XX LOC: Z+1	BAUDOT code for letter A
PAGE: XX LOC: Z+2	ASCII code for letter B
PAGE: XX LOC: Z+3	BAUDOT code for letter B
. .	.
. .	.
. .	.
PAGE: XX LOC: Z+2(N-1)	ASCII code for N'th letter
PAGE: XX LOC: Z+2(N-1)+1	BAUDOT code for N'th letter

ILLUSTRATION OF LOOK-UP TABLE ORGANIZATION FOR THE EXAMPLE PROGRAM

It is strongly recommended that beginning programmers develop the habit of first writing down the function(s) of the desired program they intend to create. Next, one should draw up flow charts as detailed as one feels is necessary to clearly show the operation of the program that is to be developed. A novice programmer will be wise to prepare quite detailed flow charts. More experienced programmers may prefer to leave out details of operations that they thoroughly understand. Flow charts should serve as ready references when the programmer goes on to actually develop the step-by-step machine language instruction sequences for the computer.

Flow charts are also an excellent method for communicating programming concepts to fellow computer technologists. Remember that general flow charts do not have to be machine specific!) Learning how to prepare and read flow charts is an important (yet easy) skill for all computer programmers to acquire. It can also be fun and a highly creative process. Using the technique, one may review the overall operation of a program under development and gain new insights into where to interconnect routines, where common loops exist (which can save valuable memory room if they are subroutined), and find other ways in which to enhance a program's capabilities.

Chapter 3 of **MACHINE LANGUAGE PROGRAMMING FOR THE "8008" (and similar microcomputers)** will appear in the September BYTE.