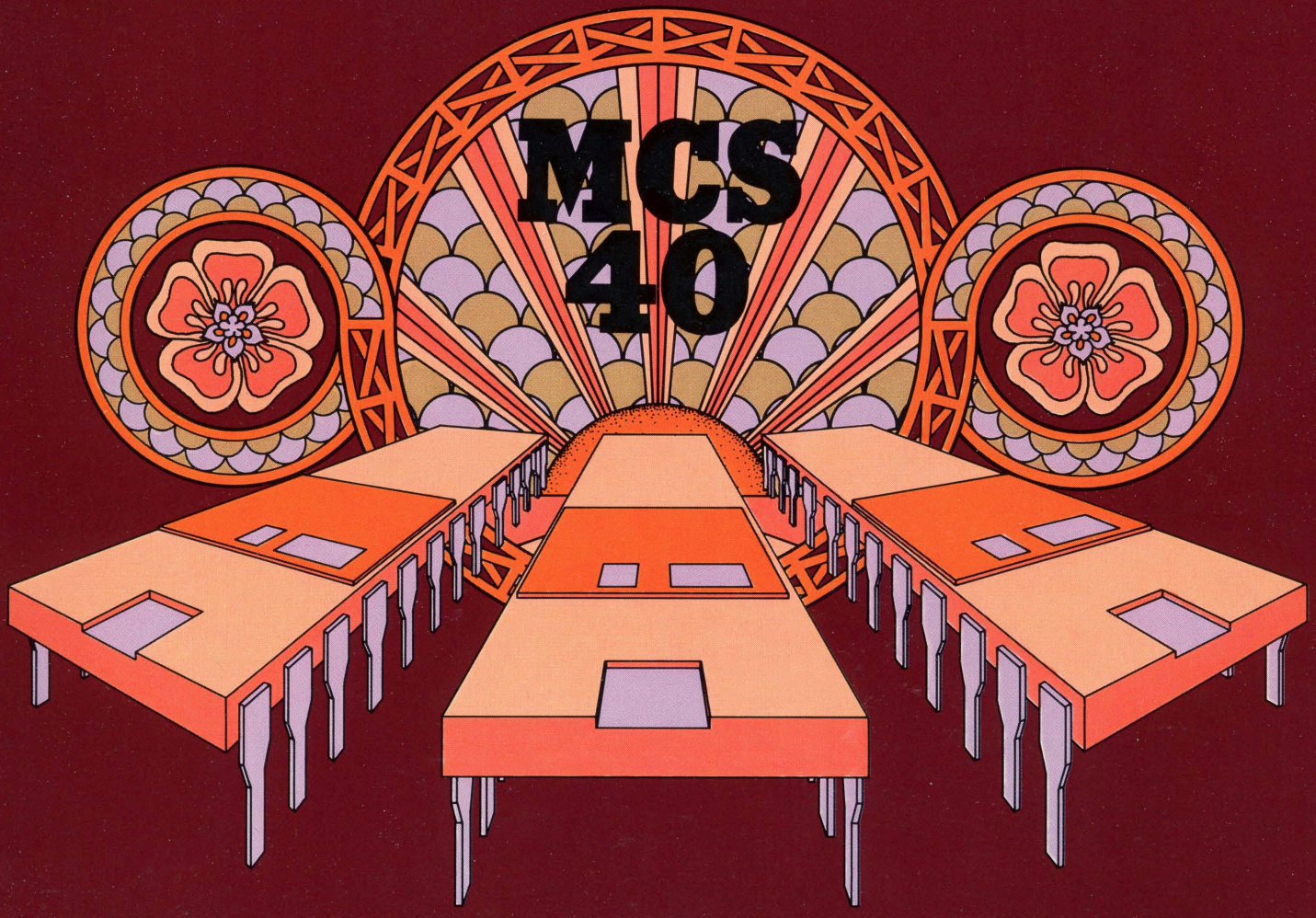
intel®

The World's Largest Selling, Low-Cost Microcomputer System MCS-40™ from Intel Corporation



The Microcomputer

A microcomputer is a highly integrated system of miniaturized devices capable of performing the functions normally associated with random logic, minicomputers and the larger central processing (CPU) units. A microcomputer replaces random logic by storing program sequences in memory, rather than implementing these logic functions with gates and flip-flops. The microcomputer has revolutionized many existing product fields and is being designed into many new areas. When connected to an ever growing family of ROM's, RAM's, PROM's, I/O devices, and clock generators, microcomputer systems can perform practically any task imaginable. New designs can be developed with fewer components, lower power and, best of all, with less money.

How a Microcomputer replaces Random Logic

Both random logic and the microcomputer interface to the rest of the system through inputs and outputs. The microcomputer replaces logic by storing a series of program sequences in memory. These program sequences perform boolean functions usually performed using gates and flip-flops. Design engineers feel they can readily replace a gate by using 8 to 16 bits of memory. If the assumption is made that the type of IC used today contains on the order of 10 gates, then one can conclude that logic can be stored in memory in a very cost effective fashion. For example, a single 2048-bit ROM can replace 128 to 256 gates or 13 to 25 IC's. Even many designs that appear to be parallel in nature can be reduced to a simple sequential microcomputer program.

Complicated timing race conditions are eliminated by using the inherent synchronous nature of the microcomputer where all timing is controlled by the central processor. The system can be readily documented and changes can be quickly made since the program is a principal element of the design. Note that the program changes in memory are actually equivalent to logic changes, but it is easier to change a program in memory than the layout of a logic card.

Available options are virtually unlimited since changes in the system are accomplished by programming. As a result, system functions may be extended or modified at any time, even after full system production has started. This allows you to sell options and custom features in your products with minimum design effort.

Intel's MCS-40™ Microcomputer Family Aids Design

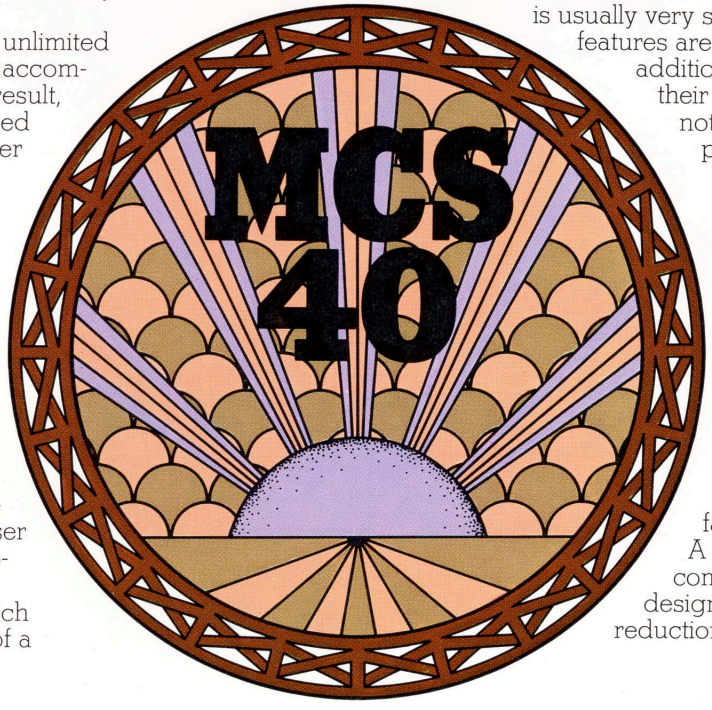
Intel introduced microcomputers with MCS-4™ in 1971. Since that time there have been significant changes. The MCS-40, Intel's expanded 4-bit microcomputer family, provides the user with a new generation of components geared for random logic replacement and all designs which require the unique advantages of a general purpose computer. Some of the features of the 4040 CPU of the MCS-40 family are:

- ☐ 60 powerful instructions
- ☐ Large number of family devices
- ☐ 10.8 microsecond instruction cycle
- ☐ Interrupt capability
- ☐ Single step operation
- ☐ 8K byte memory addressing capability and up to 5120 bits of RAM
- ☐ 24 scratch pad registers in CPU
- ☐ Subroutine nesting to 7 levels
- ☐ Instruction set includes conditional branching, jump to subroutine and indirect fetching
- ☐ Logical instructions
- ☐ Binary and decimal arithmetic modes
- ☐ CPU directly compatible with 4004 ROMs and RAMs
- ☐ Unlimited number of input and output lines.

Intel's MCS-40 microcomputer offers its users possibilities in the creation of new products and services. The economic benefits have impressed a broad spectrum of engineers and designers. Many firms are creating microcomputer designs with no other logic or programming experience.

Manufacturing costs of products can be substantially reduced by using the MCS-40. Recent Intel customer estimates of actual dollar savings in the electronic portion of systems often approach 80 per cent. The microcomputer, in fact, makes certain products commercially feasible. This has, in effect, created new industries.

Intel's MCS-40 microcomputer vastly reduces development time. Development cycles are cut by as much as six to twelve months. Once the green light is given on a microcomputer design, a typical design can take between four to ten weeks, depending on the experience level of the designer.



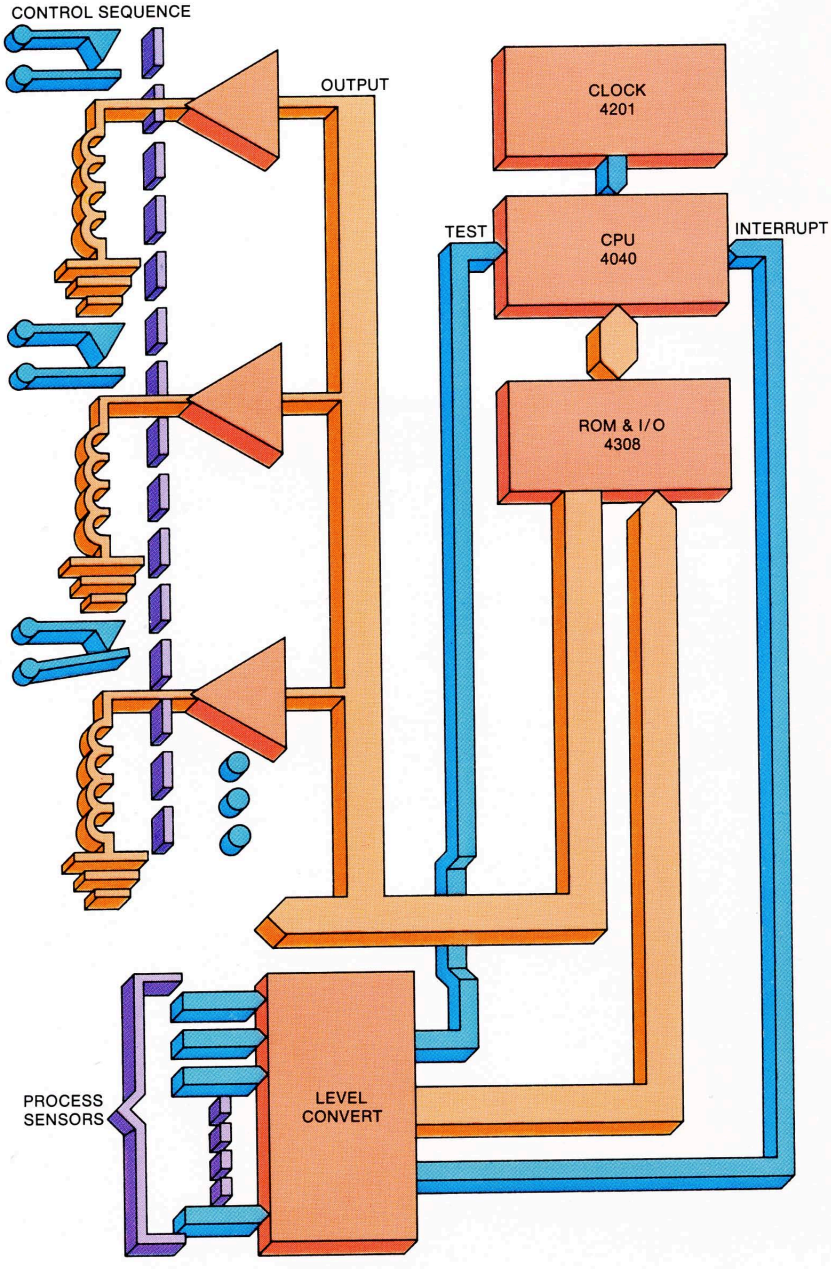
Incremental cost for adding features to the system is usually very small and easily estimated. These features are software rather than hardware additions. Manufacturers can enhance their product capability by providing not only superior products, but products which will command a higher price tag in the marketplace. Examples of added features are automatic tax computation in a cash register and traffic controllers which automatically sense traffic loads and adjust a signal's duration. The designer's imagination is the only limiting factor.

The MCS-40 microcomputer also cuts those important service and warranty costs by eliminating many IC's and the failures associated with them. A microcomputer design is less complex than a random logic design. Reduced complexity means a reduction in service calls.

Simple Process and Industrial Controller

Many MCS-40 users have increased the value of their products without significantly adding to the cost. The following application is a simple process and industrial controller which can be used for vending machines (lower cost per function); materials movement (automatic sensor detection); and machine controller (improved reliability).

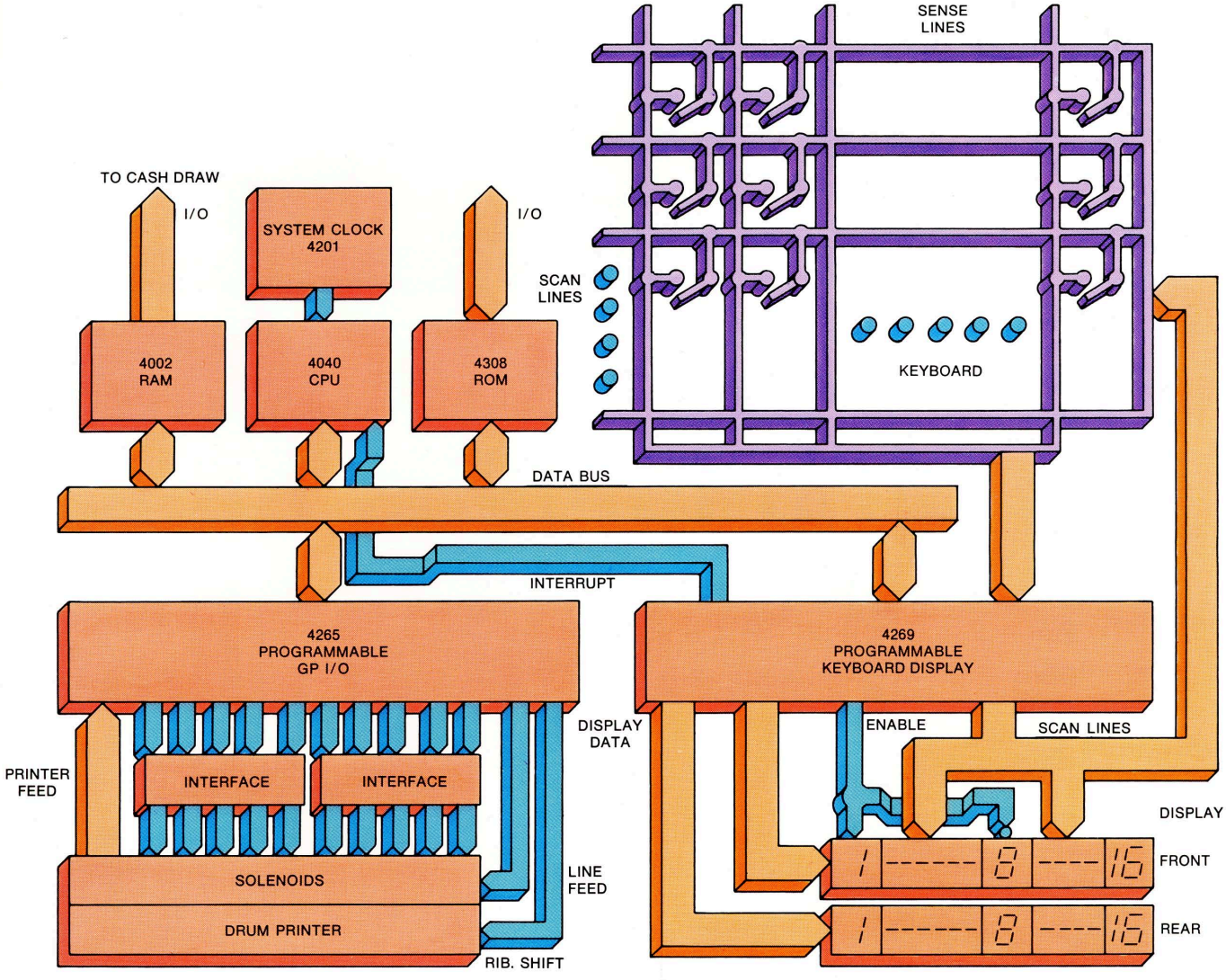
The basic process controller is implemented with three devices: a 4201 system clock, 4040 CPU and 4308 ROM with I/O. This design assigns eight 4308 input ports as process sensor inputs. These may be multiplexed to the 4308. Eight 4308 I/O lines are designated outputs and are used to drive the process actuator. These lines may be encoded to address 256 possible destinations. This system can be expanded by adding additional components to the common 4-bit bus. The expansion can allow for more process I/O or provide a communication interface to a distributed intelligence system.



Basic Printer/Display Terminal

The basic terminal design can be used in cash registers, fast food terminals, data collection systems, control stations and many other customized and general purpose applications. The basic terminal consists of some form of keyboard, display and usually a printer. The 4265 can be used to interface to most of the popular printer technologies. The 4269 provides the interface to the keyboard or switch array and automatically refreshes a display. The CPU, ROM and RAM complete the basic system. The common MCS-40 Data/Control bus allows for easy system expansion by merely adding additional components.

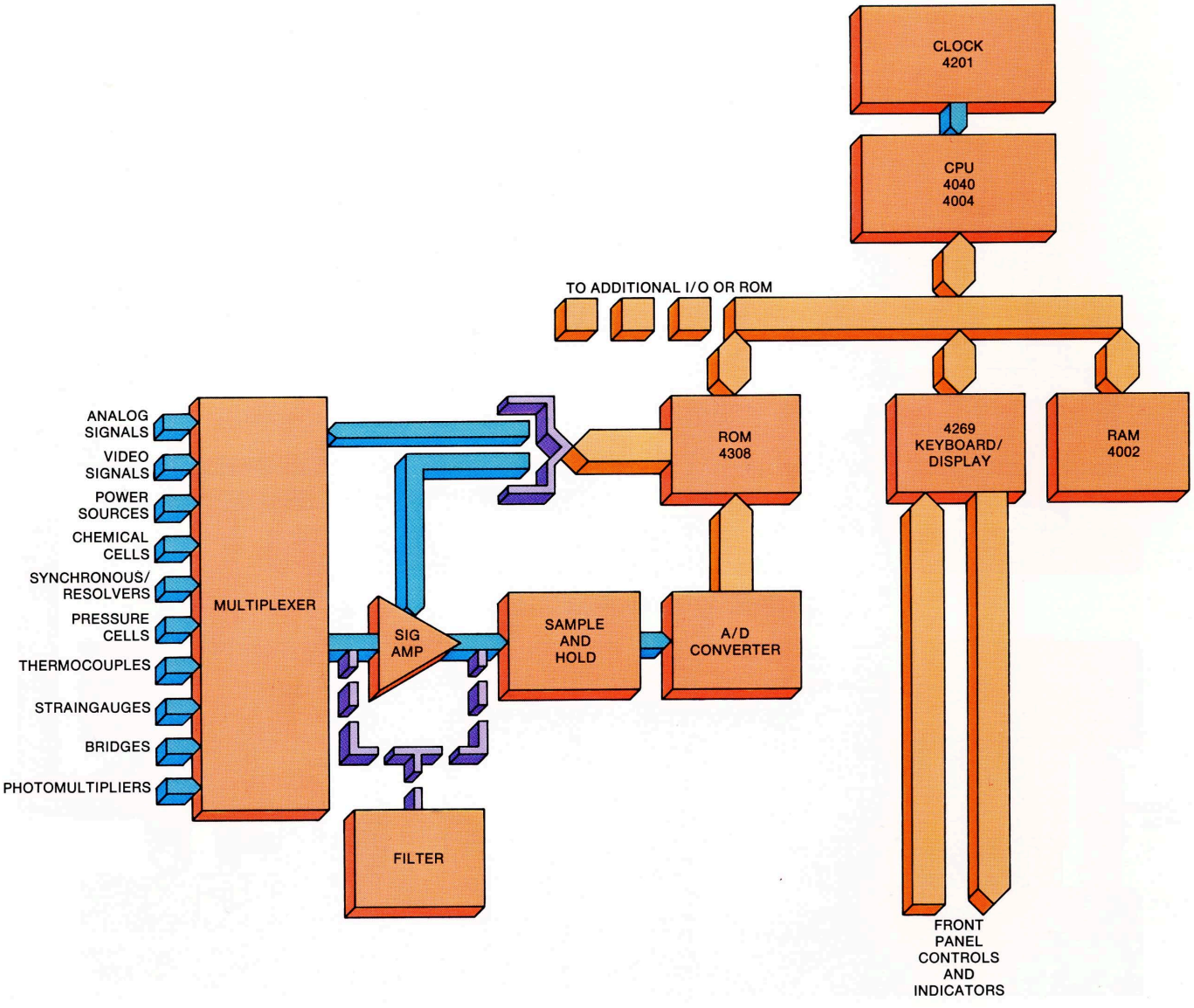
In the design illustrated below, the 4308 can be interchanged with a 4289 and 4702A combination. This allows the designer the freedom to develop with PROMs, work the bugs out, and then go to the final ROM version. This transition requires no software changes.



Instrument with Control Panel

This highly integrated system can perform decimal arithmetic, automatic calibration, and curve fitting calculations on the analog input and will display them on a scan digit display. Instruments can be made portable, due to reduced component count, hence small size and lower power consumption.

This is a typical instrument configuration with several expandable analog inputs. Each input is multiplexed to a sample and hold amplifier. The outputs of the amplifier drive the input of the A to D converter. The output of the A to D is fed in parallel to the input ports of the 4308 ROM. The system also interfaces to an array of front panel controls and indicators via the 4269 keyboard/display device. The displays and control are made functional by the MCS-40 microcomputer and can be easily redefined with a software change. Note that the 4002 RAM contains a 4-bit output port which can be used for further expansion. Through software, this system allows for changes of scales and monitoring of the instrument.

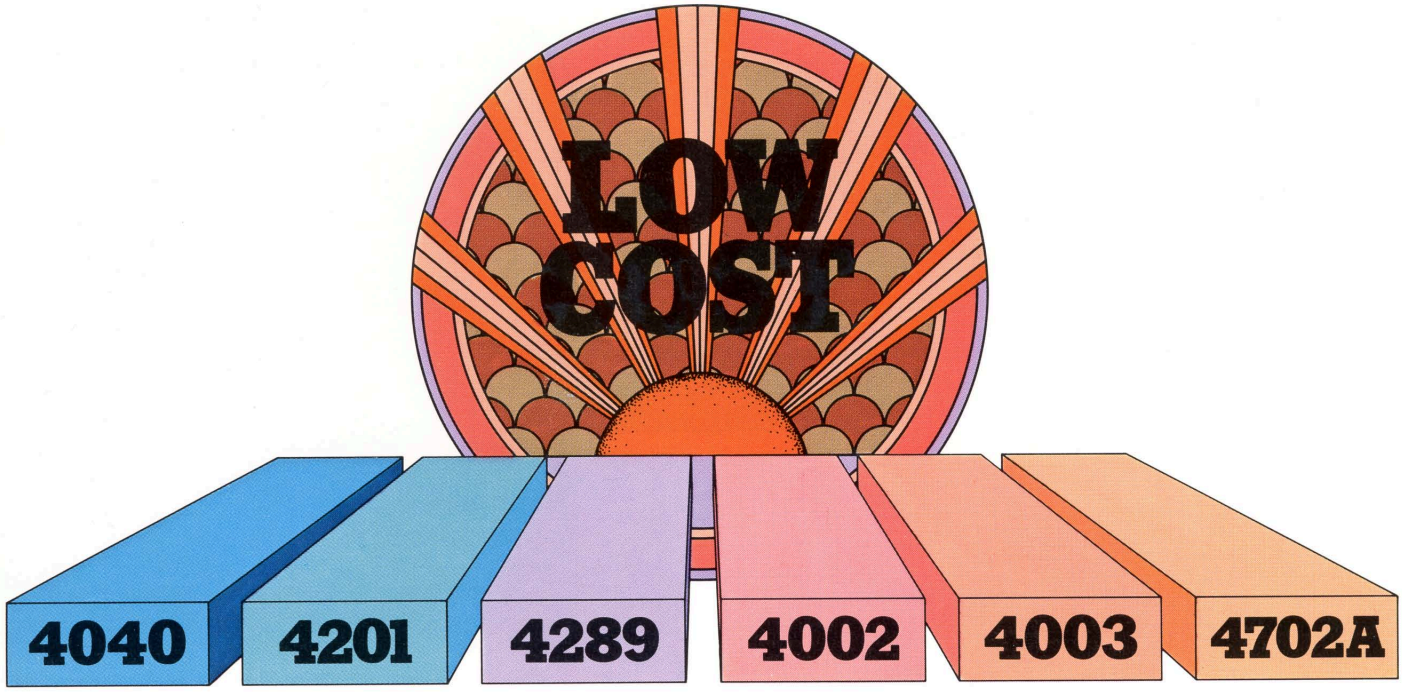


The Low Cost Development Parts Kit—MCS-40 System A

It's a snap to build your own programmable system with this easy-to-get-started system. With the high degree of modularity between all MCS-40 components, additional components can be added to this kit to tailor it to the user's special and unique application. All components are fabricated with silicon gate, low threshold PMOS technology. The following standard building blocks are found in the basic Low Cost Development System:

- ☐ 4040 CPU
- ☐ 4201 System Clock
- ☐ 4289 standard memory interface with I/O
- ☐ 4002 RAM with output port
- ☐ 4003 shift register
- ☐ 4702A programmable ROM

Order the system now and get started on your project.



The MCS-40™ is a Complete Product Line

The MCS-40 microcomputer family (the expanded MCS-4 family) is the world's largest selling family of microcomputers. This family of components has been in use for a wide variety of computer and control applications since 1971. The MCS-40 is a system which provides its users with an advanced generation of components geared for random logic replacement and all designs which require the unique advantage of a general purpose computer.

The MCS-40 comes with a comprehensive product development program consisting of hardware and software development aids and a large network of regional application engineers to draw upon. The 4040 and the 4004 CPUs are off-the-shelf, both manufactured by the world's largest manufacturer of general purpose microcomputers.

The MCS-40 Microcomputer

The 4004 and 4040 are complete 4-bit parallel central processing units (CPUs). The 4040 has a complete instruction set of 60 instructions, including Arithmetic, Interrupt, Logical Operations, I/O Instructions, Register Instructions, ROM Bank Switching, Register Bank Switching, Interrupt Disable and Enable. The 4004 has a total of 46 instructions all of which are part of the 4040 instruction set and are upward compatible.

Features

The 4040 accepts and processes a single level interrupt, the only 4-bit microprocessor in the field with a true interrupt. In the 4040, the program counter is 12 bits wide and the address stack allows for seven levels of subroutine nesting. Moreover, the register array is comprised of twenty-four 4-bit registers which can be directly manipulated by the software. This on-chip scratch pad memory enables many designs to be implemented with no additional RAM memory.

The 4040 incorporates a STOP control which enables users to halt the processor at any instruction cycle. The feature provides for "single step" operation for program and system debugging. This is a time saving advantage for any system designer.

The 4040 can address up to 8K x 8 words of ROM with no external logic requirements, which is more than most microcomputer systems will ever need.

Standard operating temperature of MCS-40 components is 0° to 70°C. MCS-40 components are also available with −40° to +85°C operating range.

More Flexible Interface

The 4040 comes with separate power supply pins for timing circuitry and output buffers. Since the output buffers have a separate power supply, they can be directly interfaced to other circuit types such as TTL, MOS or CMOS. The other MCS-40 family components in addition to the 4004 and 4040 CPUs are described in the following list:

4201
System Clock Generator

- ☐ Crystal controlled oscillator
- ☐ MOS and TTL level two-phase clock driver circuits
- ☐ Power-on reset function
- ☐ Logic necessary to implement single-step function of 4040 CPU
- ☐ Directly drives MCS-40 set

Memories

4308
Mask Programmable 8K ROM

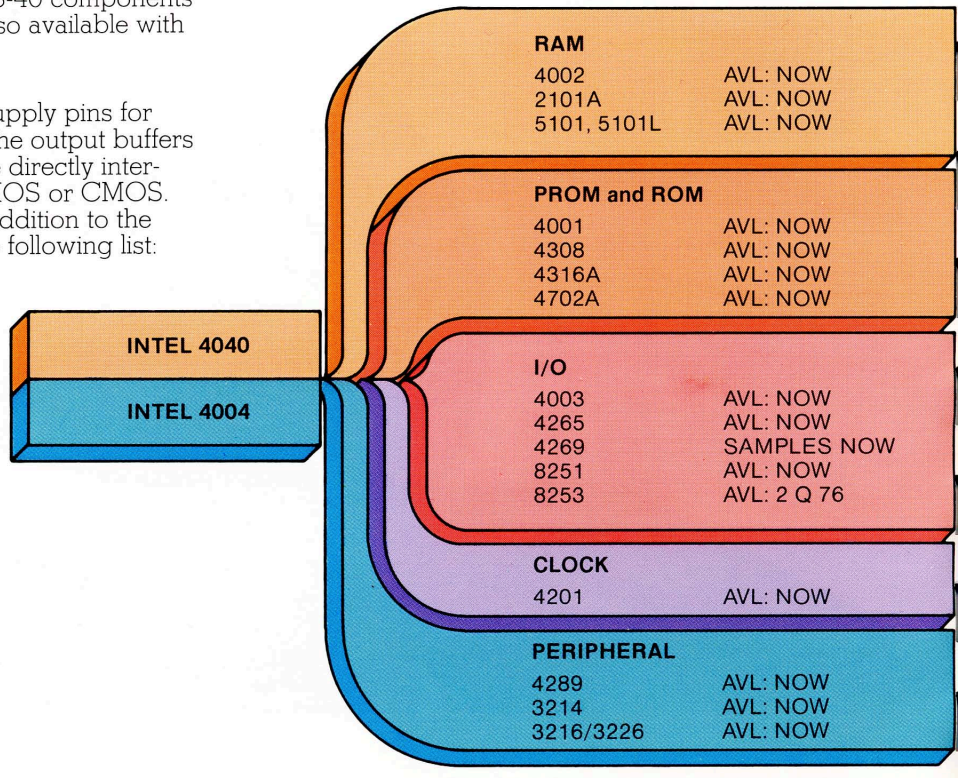
- ☐ 1024 x 8-bit program storage
- ☐ Four independent 4-bit I/O ports
- ☐ Directly TTL compatible
- ☐ Input I/O buffer storage

4001
Mask Programmable 2K ROM

- ☐ 256 x 8 program storage
- ☐ Programmable 4-bit I/O port
- ☐ TTL compatible

4002
RAM

- ☐ 320 bits organized 4 x 80
- ☐ Output 4-bit port
- ☐ TTL compatible



Input/Output Devices

4003
Shift Register
- ☐ 10 bits serial in/parallel out
- ☐ Serial-output allows for expansion
- ☐ Asynchronous clock

4265
General Purpose Programmable I/O Device
- ☐ Multi-mode 14 operating modes
- ☐ System compatible with 4289, 4308, and 4001
- ☐ 16 lines of I/O capability
- ☐ Bit set/reset
- ☐ Multiplexible outputs
- ☐ 8-bit transfer mode
- ☐ Interfaces to 8080 peripherals
- ☐ Synchronous and asynchronous interface
- ☐ Strobed buffer inputs and outputs
- ☐ TTL interface
- ☐ Up to eight 4265 per system
- ☐ Interface to standard RAMs
- ☐ Directly MCS-40 bus compatible

4269
Programmable Keyboard Display I/O Device
- ☐ 8 x 8 self-scanned matrix
- ☐ Interfaces to switches
- ☐ Each matrix coordinate produces unique 8-bit code
- ☐ 2-key roll over
- ☐ 8 character FIFO buffer
- ☐ Generates interrupt on character entry
- ☐ Fixed keybounce delay of 11 m sec.
- ☐ Status buffer to indicate keyboard overentry
- ☐ Continuous sensor scan mode
- ☐ Two 4 x 16 display register for LED, PANAPLEX, NIXIE or INCANDESCENT displays
- ☐ Burroughs Self-Scan® display mode
- ☐ Access to internal registers under program control
- ☐ Up to four 4269 devices per MCS-40
- ☐ Directly MCS-40 bus compatible

4008/4009
Standard Memory Interface Pair
- ☐ Direct interface to PROM's
- ☐ Unlimited I/O expansion
- ☐ Direct interface to all standard memories

4289
Standard Memory Interface
- ☐ Direct interface to all standard memories: TTL, NMOS, PMOS, CMOS
- ☐ Direct interface to all PROM's
- ☐ Allows READ AND WRITE program memory
- ☐ Unlimited Input/Output expansion
- ☐ Single package equivalent of 4008/4009

Supplemental Devices

The following devices are supplemental and are compatible with the 4008/4009 and the 4289.

4702A
Erasable and Electrically Reprogrammable ROM
- ☐ 2048 bits, organized 256 x 8
- ☐ Fast programming—2 minutes for 2048 bits
- ☐ Inputs and outputs TTL compatible
- ☐ Three-state outputs
- ☐ Alterable Program Memory in system development

4316A
Mask Programmable ROM
- ☐ 16, 384 bits, organized 2048 x 8
- ☐ Fully decoded

2101A
RAM
- ☐ 1024 bits—organized 256 x 4
- ☐ Static operation
- ☐ Fully decoded
- ☐ TTL compatible
- ☐ Three-state outputs
- ☐ Used for writeable Program Memory

5101, 5101L
RAM

Same as the 2101, but CMOS which allows for low power operation and battery stand-by.

8-Bit I/O Devices

The following are 8-bit devices which interface to an MCS-40™ CPU via the 4265 Programmable General Purpose I/O.

8251
Programmable Serial Communications Device
- ☐ Synchronous and asynchronous operation
- ☐ Baud Rate—DC to 56K Baud (Synchronous Mode)
  —DC to 9.6K Baud (Asynchronous Mode)
- ☐ Full duplex, double buffered transmitter and receiver
- ☐ Error detection—parity, overview, and framing

8253
Programmable Interval Timer

(Available 2nd Quarter 1976)
- ☐ Three independent 16-bit counters
- ☐ Programmable counter modes
- ☐ Counts binary or BCD

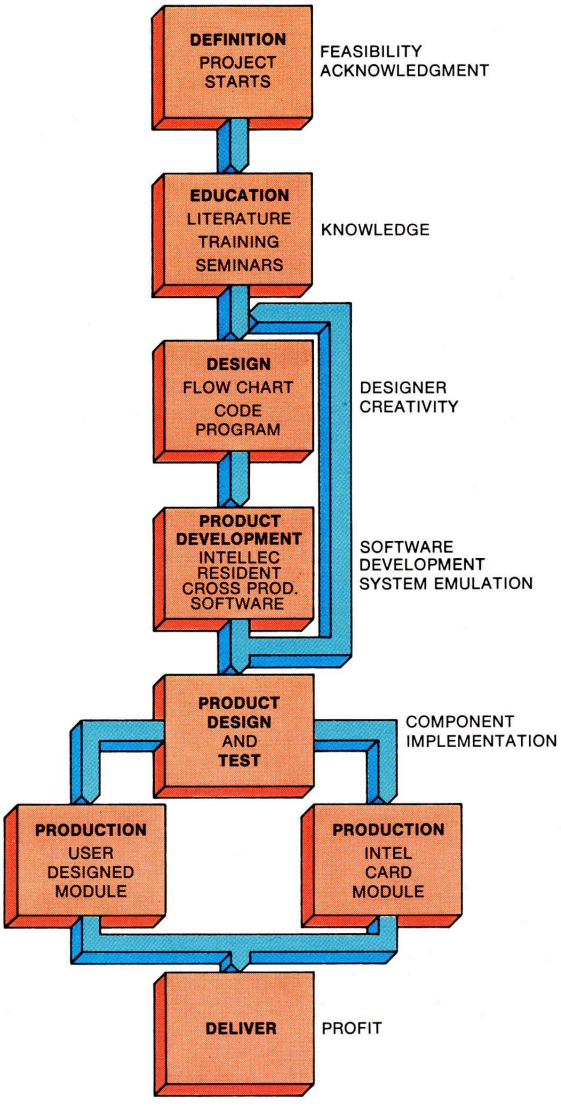
Peripheral Devices

3214
Priority Interrupt Control Unit
- ☐ Eight priority levels
- ☐ Current status register
- ☐ Priority comparator

3216/3226
4-Bit Bidirectional Bus
- ☐ Low input load current
- ☐ High output drive
- ☐ Three-state outputs
- ☐ Inverted (3226) and non-inverted (3216) operations

Designing with a Microcomputer

The diagram below illustrates the typical procedure used in a formalized product design program. Intel is prepared to assist you at every stage of your design activity.



Definition

The first step in a successful design program is to apply the microcomputer in the context of an accurate definition of the project. This must be accomplished by a feasibility study. Next, a viable proposal, clearly listing the parameters of the entire project, should be presented. The proposal becomes an amalgamation of engineering and marketing input. Features and techniques are carefully examined.

Education

Utilizing a microcomputer in a design requires familiarization with a specific computer set. Acquisition of Intel's wide array of available literature is an excellent first step. In-plant seminars can be conducted to provide in-depth product information and increased familiarity. Exact specifications are supplied and precise project cost can be evaluated. Intel's education process is carefully formulated to provide all the necessary training required to successfully complete the project. To assist you in achieving this, Intel offers regularly scheduled three day courses at regional locations throughout the country.

Flow Chart

Creativity keynotes the sequential designer's flow chart which is indispensable to the project and its swift completion. A flow chart is a pictorial description of the design and sequentially describes the end product. From the flow chart, programs can be generated and a system assembled that is easily understood. Intel's field engineering support team is ready to provide advice or assistance on the design decisions that will be faced.

Product Development

Intel offers two methods to the designer for his use in developing the system. Both feature speedy product development and are fully supported by Intel.

The Intellec® 4/MOD 40

This is a complete, self-contained microcomputer development system designed to support the development and implementation of 4004 and 4040 CPU based microcomputer systems. Its modular design provides the user with a self-contained development laboratory. The best thing about the Intellec is its ease of use. Every Intellec 4/MOD 40 comes with two systems software products—the PROM resident system monitor and the RAM resident assembler. The system software is a powerful application program development tool.

The system monitor provides the capability of displaying and modifying memory contents, reading and punching object (program) tapes, dynamically assigning system peripherals, programming and verifying PROM's and also performing other functions which significantly reduce both program debug and development time.

The Intellec 4/MOD 40 RAM resident assembler translates source code mnemonic format into object code which will execute on the Intellec 4/MOD 40 or any MCS-40 system. The assembler collects information from the source program and builds an internal symbol table, outputs a listing of the assembled program (including error messages) and can punch or list the object program. The teletype and reader serve as a convenient vehicle to input/output information from the Intellec system.

The basic Intellec 4/MOD 40 system consists of four microcomputer modules (CPU, RAM, MEMORY CONTROL, and PROM PROGRAMMER), power supplies, I/O connectors, console, and displays. The imm6-76 PROM programmer module provides the capability of programming Intel® 4702A PROM's in conjunction with the front panel PROM socket and system monitor.

The user RESET, IN/OUT, STOP/STOP ACKNOWLEDGE, and INTERRUPT/INTERRUPT ACKNOWLEDGE control signals are all available at the back panel. Hence, the user can interrupt, halt, and reset the resident CPU via his own interface.

Program interrogation and alteration can be accomplished by using any desired combination of the front panel designer's console, a teletype, the imm4-90 high speed paper tape reader, and other Intellec compatible peripherals. The front panel designer's console provides the capability of manually writing data into memory and displaying memory contents, monitoring CPU bus contents during each processor subcycle, "freezing" system status after execution of a predefined instruction following a specific number of passes, single-stepping the program and verifying program flow.

MCS-40™ Cross Software Development Tools

Programming for the MCS-40 can be done easily and quickly using Intel's new cross macroassembler, MAC 4. This powerful assembler translates three letter mnemonics representing each MCS-40 instruction into a binary format that may be loaded directly into an Intellec development system or programmed directly to ROM. Advanced MAC 4 features provide full macro capability and conditional assembly capability. All output is hexadecimal for easy interpretation.

MAC 4 is written in ANSI standard FORTRAN IV and is designed to run on any large scale computer system (32 bit word size or larger) with little or no modification. The FORTRAN source program for MAC 4 is available on magnetic tape directly from Intel. In addition, MAC 4 may be used on either TYMSHARE, UNITED COMPUTING SYSTEMS or GENERAL ELECTRIC Worldwide time-sharing service, and may also be used on Timesharing Ltd. in Europe. Contact these services directly for further information.

A simulator program called INTERP/40 is also available. This program provides a complete software simulation of MCS-40 programs. INTERP/40 is written in ANSI standard FORTRAN IV and thus allows the designer to debug software interactively on any large computer system.

MCS-40 User's Library

The MCS-40 Library is a collection of programs written by users of the 4004 and 4040 CPU systems and contributed to the library to benefit all MCS-40 users. Intel will make source listings of all programs and detailed instructions on their use available to all members of the MCS-40 User's Library. To become a member simply:

1. Submit a program to the library with detailed documentation and a complete user's library submittal form, or
2. Pay a nominal yearly membership fee.

For more information on how you can become a member, please contact your local Intel representative.

Product Design and Development

During the important design and development phase, there are two options available to you: you may use Intel's designed cards, such as the Intellec CPU cards or you may develop your own component design. During the product design and testing phase, Intel will make every effort to assist you in component implementation via our regional application engineers.

Delivery

Profit follows delivery of your completed product. By using Intel's MCS-40 and following our step-by-step design program, your superior products will enter the market faster and with considerable savings in development cost.

Each Intel system has the same high support level. Intel will help you choose the system best suited to your needs. Fill out the attached postage paid reply card. Send it to us and we'll assist you in putting the remarkable MCS-40 to work in your system. Today.

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