INTRODUCTION

Large scale integration technology has produced microprocessors with an assortment of input-output circuits, peripheral devices and memory components. They form a family of versatile logic elements whose operational characteristics can be defined simply by means of a software program stored in memory. This feature identified microcomputers as programmable logic devices, capable of performing a wide range of measuring, monitoring, controlling and data processing functions. They promise to be a new tool in the cost-effective realization of many dedicated control and process applications, which were not economically realizable prviously using conventional digital computing elements.

The low cost of microprocessors and support devices is very misleading due to the high priced engineering and programming effort needed to integrate them into final operational systems. The design of a special microcomputer for a particular application is completely uneconomic in small volumes. To enable economic usage of microprocessors in low volumes, DAI manufactures a complete family of standard microcomputer and interface modules. With these fully-tested modules a user can assemble a complete operational system in a short time.

DAI microcomputers and 'Real-World' interface cards provide a set of easy-to-use hardware building blocks. They enable every user to benefit from the economic and technical advantages offered by microprocessors, with minimum involvement in their technology.

DAI workshop programs teach all the skills necessary to implement operational systems using DAI microcomputer and interface modules. Complete newcomers to digital computer and programming concepts find they can complete working systems during the course. These 3-day workshops are arranged regularly by each local DAI representative, and include comprehensive hands-on experience.

1.1 THE DCE PHILOSOPHY

The DCE (digital control element) family of microcomputers and "Real-World" interface cards were designed to free the designer as much as possible from the problems of hardware design and development, product testing, packaging requirements and low volume component costs. They enable designers, who may not necessarily be computer design experts, to reap the benefits of this new technology even in low and medium volume applications. Being totally independent of the commercial interests of microprocessor manufacturers while working in close co-operation with them, has enabled DAI to freely select the best LSI components in the market, and design the DCE product family for optimum cost-performance.

The DCE product family provides the designer with a comprehensive set of tested hardware, software and package compatible eurocard modules, which can be easily assembled to realize any real-life system. Since all of the hardware modules are burned in and fully logic tested before leaving the factory, the designer does not have to invest in expensive test instrumentation. The cost of system maintenance and eventual troubleshooting is also reduced simply to module exchanging.

All DCE microcomputers and Real-World interface modules have three features in common:

- single eurocard format
- software compatible
- package compatible

DCE microcomputer compatibility means that once any DCE is designed into a particular application, it can easily be updated by another DCE. When additional requirements or changes are needed, they can usually be satified with software changes alone.

1.1.1 DCE Microcomputer Cards

The DCE single eurocard (100 x 160 mm) microcomputers provide the digital computing power of popular 8 or 16 bit microprocessors enhanced by fully implemented serial and parallel I/O capability, program and data memory, independent interval timers and fully vectored interrupts. The serial communication interface is opto-isolated, has programmable baud rates, and can be interrupt driven. The parallel I/O lines can be software programmed as input, output, bi-directional or handshaking ports, with automatic generation of handshake control signals.

The DCE-1 and DCE-2 microcomputers have sockets for 1K (2708) EPROMs, while DCE-1A and DCE-2A have sockets for 2K (2716) EPROMs. The memory expandable DCE-X along with memory expansion cards provide up to 64K memory capacity. These microcomputers are all based on the 8-bit 8080 microprocessor, and are software compatible. The DCE-X86 microcomputer based on the 16-bit 8086 microprocessor has sockets for 2K (2716) EPROMs, and is memory expandable up to 64K words.

1.1.2 Real-World Card Concept

A "Real-World" card is a connection between the digital world of the DCE microcomputers and the real-world of analogue voltages, heavy currents, noisy industrial signals, data communication, contact closures and other real-life phenomena. The designer simply inserts these RWC cards in any combination up to 15 along with a DCE card and a power supply module into the parallel wired eurocard rack or box. Each RWC has a hexadecimal switch for address setting, and the DCE communicates with them via the DCE-BUS using the Real-World software subroutines provided.

The number of RWC cards available has steadily grown to meet the demands of almost every possible application.

1.1.3 DCE Development Tools

By following a new design philosophy, DAI has eliminated the need for expensive dedicated development systems and emulators for developing and debugging system software and hardware.

By utilizing the Bus Monitor Card, PROM Programmer Card, PROM resident software development assistance modules and a software package, the designer can easily turn the euro-rack with DCE and RWC cards into a low-cost development system with advanced features. He then has powerful debugging tools for testing the software, as well as the software/hardware interfaces in his system.

With the aid of the Utility package the designer can insert his program and interrupt routines into RAM, display and modify the register and memory contents, trace the program while running, perform I/O operations, program and verify EPROMs.

BASIC and FORTRAN packages extend all the advantages of high-level programming languages into DCE systems at a minimum cost.

1.2 GENERAL DESCRIPTION

The user can consider the DCE as a logical building block which he connects to his peripheral devices and circuits. The control function of this logic block is determined by a sequence of instructions (contained in the PROM memory of the DCE processor card) into which the system function has been encoded. Accordingly, it produces output signals to drive user-connected peripheral devices and circuitry.

Between the input from and the output to a peripheral device, there is the process phase during which logical operations, calculations, comparisons, analysis, and data exchange between memory and peripherals can take place. Due to its interrupt handling capability, the DCE can perform multiple real-time tasks simultaneously; for example, message transfer and main program execution.

1.2.1 DCE I/O Architecture

DCE microcomputers contain two powerful LSI subsystems to permit the designer to handle complicated serial and parallel I/O operations with simple instructions:

* The General Interface Control (GIC) provides 24 programmable parallel I/O data lines.

* Timer Interrupt and Communications Control (TICC) provides 5 interval timers, 8 level vectored priority interrupt control, serial data communications with programmable baud rates and 2 parallel data ports.

All input and output ports of the DCE have memory addresses and can be treated as simple memory locations. The DCE-BUS concept allows simple connection to a wide range of external devices via the Real-World interface cards.

1.2.2 General Interface Control (GIC)

The GIC provides 24 parallel input/output lines through three 8-bit general purpose interface ports (Port 0, Port 1, Port 2) as shown on the block diagram in Figure 1-1. These ports can be software programmed independently to serve as input, output. bi-directional

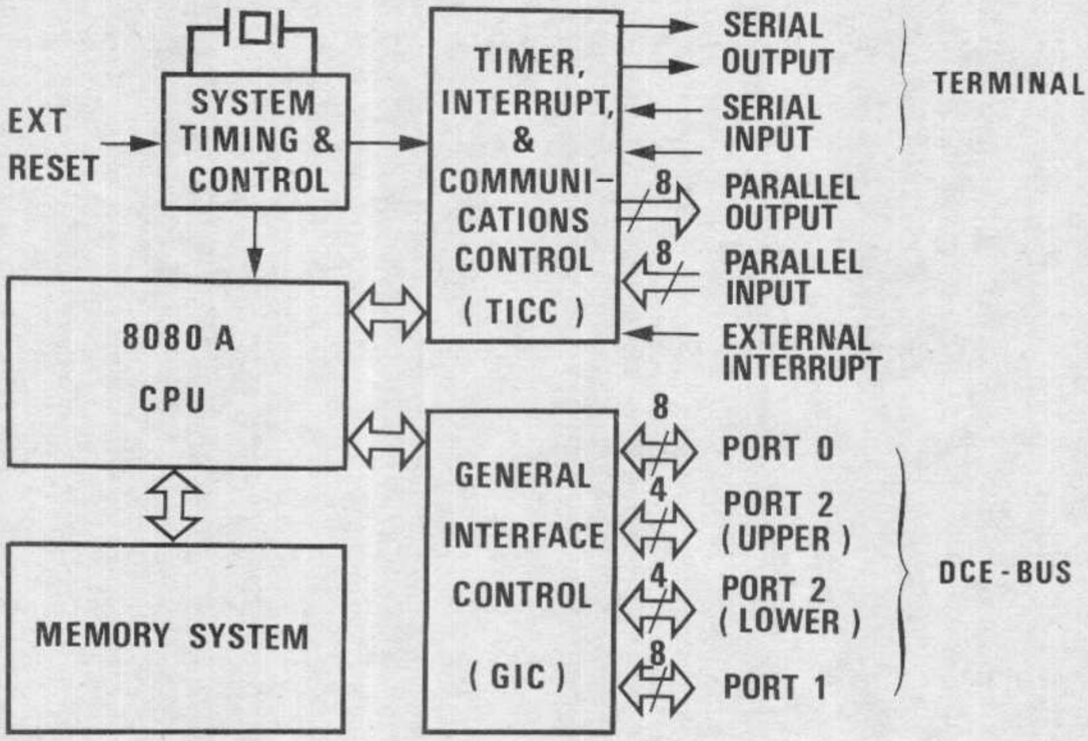

Figure 1-1. General DCE Processor Block Diagram for 8-bit Microcomputers

or handshaking with automatic generation of handshake control signals. Through selected bits or groups of bits of these ports the user can input or output data directly to or from the CPU.

When the DCE microcomputer is used with RWC interface cards, the GIC I/O lines are configured in a special way to implement the DCE-BUS.

There are three modes of I/O operation:

1. Simple Input-Output

   In this mode data is simply written to or read from a specified port; no handshaking is required. While the output in these modes are latched, the inputs are not.

2. Handshaking Input-Output

   The following handshake control signals are automatically generated and processed by the GIC.

   Input Buffer Full
   Output Buffer Full
   Data Strobe
   Data Acknowledge
   Interrupt Request

   While ports 0 and 1 are devoted to Data I/O, selected bits of port 2 pass the handshake control signals. No program steps are necessary to generate, process, or coordinate the handshaking signals.

3. Bi-directional Input-Output

This mode, available for port 0 only, provides the facilities for transmitting or receiving information to or from a peripheral device through a single 8-bit bus. Handshaking signals maintain the proper bus discipline. In this mode inputs and outputs are latched independently from each other.

1.2.3 DCE-BUS Concept

The DCE-BUS provides a common transfer medium for the exchange of data and control information between DCE-BUS compatible processor and interface modules.

It is usually driven by the GIC on the master DCE processor, configured to provide 8-bit input/output data transfer, read and write control signals, two external interrupt requests and eight address control lines for selective access of modules on the bus. Each interface module is plugged into the DCE-BUS through the system connector and given a unique address via a hexadecimal switch on the module. Slave DCE processors are given software defineable addresses. The DCE-BUS can also be hardware driven if necessary for faster operation.

Read and Write subroutines are provided to simplify the transfer of data between DCE processor cards and Real-World interface cards via the DCE-BUS. The designer therefore has a simple means of providing information transfer between many logically and physically separated interface functions, via the master processor. For example, data from an anlogue input channel could be used to control an output device connected to a different interface card.

The DCE-BUS provides the facility to simultaneously connect upto 30 bus compatible Real-World modules and a large number of slave DCE processor modules to a single master DCE processor module. Bus usage between the different processor modules is determined by system software controlled by the master. The DCE-BUS supports the normal software driven bus exchanges, as well as the more powerful high-speed bus transfers generated by hardware.

1.2.4. Timer, Interrupt and Communications Control (TICC)

The TICC provides (in addition to the three 8-bit ports of the GIC) an 8-bit parallel input and an 8-bit parallel output port, 5 interval timers, 8 level vectored priority interrupt control and serial data I/O with programmable Baud rates.

The opto-isolated serial channel is software programmable for Baud rates of 110, 150, 300, 1200, 2400, 4800 and 9600, totally under the control of TICC. This implies that during serial data transmission or reception the CPU can continue the control function to which it is dedicated. At the end of transmission or reception of a character, the TICC interrupts the CPU. The program will then branch to a respective vector routine that handles data transfer between I/O buffers and memory. This feature makes the DCE ideal for real-time message transfer and simultaneous control work.

In addition, the five interval timers of the TICC make the DCE adaptable for simultaneous execution of five control functions at various priority levels. These timers are 8-bit counters. The time interval they provide, vary from 64 to 16,320 micro-seconds (for longer intervals the programmer must cascade timers). With a single instruction, the program loads a timer with a number corresponding to the desired time interval. Loading the timer activates it, and it starts counting down in decrements of 64 micro-seconds. When the count reaches zero an interrupt causes the program to branch to a service routine. In the place of TIMER No. 5 an auxiliary external interrupt input can be selected via a software switch.

Another interrupt-generated program branch can be induced via the external interrupt input.

The eight vectored interrupt sources provided by the TICC have different priority levels, and each can be enabled or disabled individually by programming bits in the interrupt mask register.

1.2.5 Programming

The 8-bit DCE microcomputers are software compatible with the instruction set of 8080 microprocessor, while the 16-bit DCE microcomputer is based on the 8086 CPU. Sockets for erasable PROM memory are provided on the microcomputer card or on a separate memory card, depending on the type of DCE in use. The RAM memory, supplied on the cards, allows storage of intermediate results, I/O buffering, and serves also as the CPU stack memory.

A range of software modules are available to assist the development and testing of software for DCE systems.

1.2.6 Testing

The testing of a complex hardware system such as the DCE can represent a major problem even to the most experienced microcomputer system designer. For this reason, DAI has devoted a considerable amount of effort to the development of a dedicated automatic test system that fully tests each module. The fact that every card is burned in and fully logic tested before leaving the factory represents one of the most profitable advantages of the DCE technology.

1.3 CUSTOMER SUPPORT

DAI was founded in 1971 as an engineering and consulting company to exploit microprocessors. It has grown to the position of a world leading company for microcomputer engineering by designing and implementing a large number of microprocessor based systems. Operational DAI systems cover a very wide range of applications all over the world.

DAI developed the concept of microcomputer workshops, and has trained thousands of engineers in Europe. Every major semiconductor manufacturer has successfully used the DAI workshop program.

The accumulated know-how and unique experience of DAI is made available to the complete spectrum of microprocessor users via DAI Standard Modules, Custom Controllers and Minimum-Cost Devices.

DAI Standard Modules provide a set of hardware building blocks ideal for low-volume applications. They provide a short-cut for the electronic engineer, and a packaged solution for engineers from other disciplines. There are described in detail in this manual.

In medium volumes, a special development to combine all the components necessary for a particular application on a single printed circuit card is more economical. DAI Custom Controllers satisfy this need. DAI accepts complete design and engineering responsibility to deliver a programmed, assembled and tested custom controller card performing to user specifications. These Custom Controllers are ideal for users who want to apply microprocessors with no involvement in their technology.

For high volume applications such as consumer products the component count is critical. In such cases DAI will design and program the system to yield a single-chip microcomputer based product with as few components as possible. A major design effort is devoted to eliminating even the smallest components. In spite of these high design costs, the final unit cost will be very low for large production volumes. DAI Minimum-Cost Devices open up many new and unexpected microcomputer applications in high volumes.

Finally, if a project needs a quick and cost-effective solution, DAI can provide a turn-key solution by supplying the complete microcomputer system with all interface logic and necessary software.

All the products and services of DAI are available locally via a worldwide network of representatives. They regularly conduct DAI microcomputer workshops, and provide local customer support.