



Circuits for modular design of consumer and industrial products – the CLIPS system

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Many design projects meant for 8-bit implementation, even for entirely different applications, look remarkably similar. Consider four different and seemingly unrelated application areas: telecommunications, industrial control, instrumentation, and home video/audio. How are they alike?

Well, let's further consider some typical 8-bit applications within these areas:

- a telephone set
- a process control monitor
- a digital voltmeter
- a tv controller.

None of these applications will require a high data throughput, but all will probably be pushed for space; serial data communication is therefore a must. The use of serial links also results in an overall cost saving compared to parallel data connections. Fewer pins means smaller packages on smaller boards and cheaper encapsulations; less wire means cheaper interconnections and simpler layouts.

In addition, each application will usually require some form of intelligent control, an 8-bit single-chip microcomputer being the best candidate. Finally, all will include a number of identical peripheral circuits: additional RAM, I/O expanders, LCD drivers etc. In fact, the only difference between them is to be found in the dedicated peripheral circuits which perform the specific application-oriented tasks, and the software resident in the microcontroller. The telephone set, for example, will require a ringer circuit, transmission circuit and, possibly, a DTMF dialler; the voltmeter, (or process controller) will need D/A and A/D converters; the tv will have to include special tuning circuits and a remote control facility.

In all these application areas, the combination of general-purpose and dedicated circuits can be found. Introducing standard products and design techniques for applications as diverse as these, leads to wide-ranging benefits:

- The designer is able to adopt a 'building block' approach, going straight from block diagrams to circuit implementation knowing that compatibility and interfacing problems are already solved.

Such an approach leads to a straightforward, structured hardware design. Each device on a circuit board can immediately be recognised as fulfilling a particular function. Upgrading is then done simply by adding extra devices to perform extra functions. One-to-one recognition of functions-to-ICs also means easier diagnostics and repair, as functional problems can be immediately linked to particular devices.

Structured hardware also leads naturally to modular software. If the same types of microcomputer are used continuously, a library of reusable software modules can be built-up to cover control needs for a variety of peripherals in many different application areas.

- The manufacturer could build up a family of products by simply adding or subtracting dedicated peripheral circuits.
- The component manufacturer would be able to produce large volumes of the same group of ICs for a wide variety of applications, thus keeping costs low: the dedicated devices would be added to the component range to match the demand from each product area.

THE CLIPS CONCEPT

To realise this 'building block' approach, a complete range of products is needed. To be at all feasible this range must include:

- low-cost industry-standard microcomputers
- general-purpose peripheral circuits
- application-specific peripheral circuits
- a versatile interconnecting bus.

Philips is introducing such a range under the collective designation CLIPS (Consumer and Industrial Peripheral Set). The aim of CLIPS is to create a design environment in which devices can be 'clipped' on to a bus. Therefore, numerous ICs with the necessary serial I/O are being released to interface with the Inter-IC (I^2C) bus (Ref.). Incorporating the hardware capable of supporting the I^2C bus directly on-chip enables the designer to concentrate on the functional aspects of a system without having to worry about the communication link between the different system parts.

To cover a broad range of applications, including battery-powered operation, most CLIPS circuits will be CMOS devices; because of its high noise immunity CMOS is ideal for noisy industrial and automotive applications. The specification of the I^2C bus, however, permits devices using any type of technology (CMOS, NMOS or I^2L) to be connected together in one CLIPS system. Besides standard DIL, all CLIPS circuits are also available in SO (Small Outline) packages.

CLIPS circuits are also adaptable to further integration. A typical system can be considered as various general

purpose devices — microcomputers, LCD drivers, I/O expanders, extra memory (Fig.1), with specific application-oriented devices tagged on. If a particular CLIPS system has been successfully used in large numbers, the specific combination of devices can be integrated with the existing general-purpose devices. Separate microcomputer and A/D converter ICs, for example, can easily become one unit, with circuit functions and system performance remaining the same.

Standardisation within CLIPS systems leads to more economical use of any software developed. Modular application software can be used again and again in a variety of applications, carrying out the general-purpose functions within a CLIPS system. Subroutines associated with implementing a particular CLIPS IC will also be included in the support material for that circuit as an aid to designers.

CLIPS APPLICATIONS

The range of CLIPS applications is as wide as the microcomputer field; the following examples merely give an indication of the range and possibilities of CLIPS circuits.

Video entertainment and information centre

Video games, teletext and home computers are transforming tv sets from mere receivers of broadcast programmes to complete entertainment and information terminals. As extra features are introduced the tv receiver must be able both to accept them and integrate them into a user-friendly home appliance.

Let us consider a top-of-the-range tv set including at least a remote control, a games interface, and viewdata capability. The Fig.2 block diagram shows how these, as well as other functions, might be served by a CLIPS system. Using CLIPS, it is possible to relate each block to an equivalent IC.

A point worth noting is the use of the remote control receiver within the system. Since the microcontroller associated with this device has to be active all the time, it is best implemented in CMOS. The I^2C bus supports devices in any of the major manufacturing technologies and therefore allows each IC in the CLIPS system to be realised in the technology best suited to its function.

The D²B interface (see Ref.) enables the tv to be linked to other 'intelligent' appliances, such as a VCR or video camera, which themselves benefit from CLIPS implementation.

Subscriber telephone set

The CLIPS implementation of a subscriber telephone set includes all the functional units usually found in top-of-the-range models (Fig.3). The RAM is additional to that found

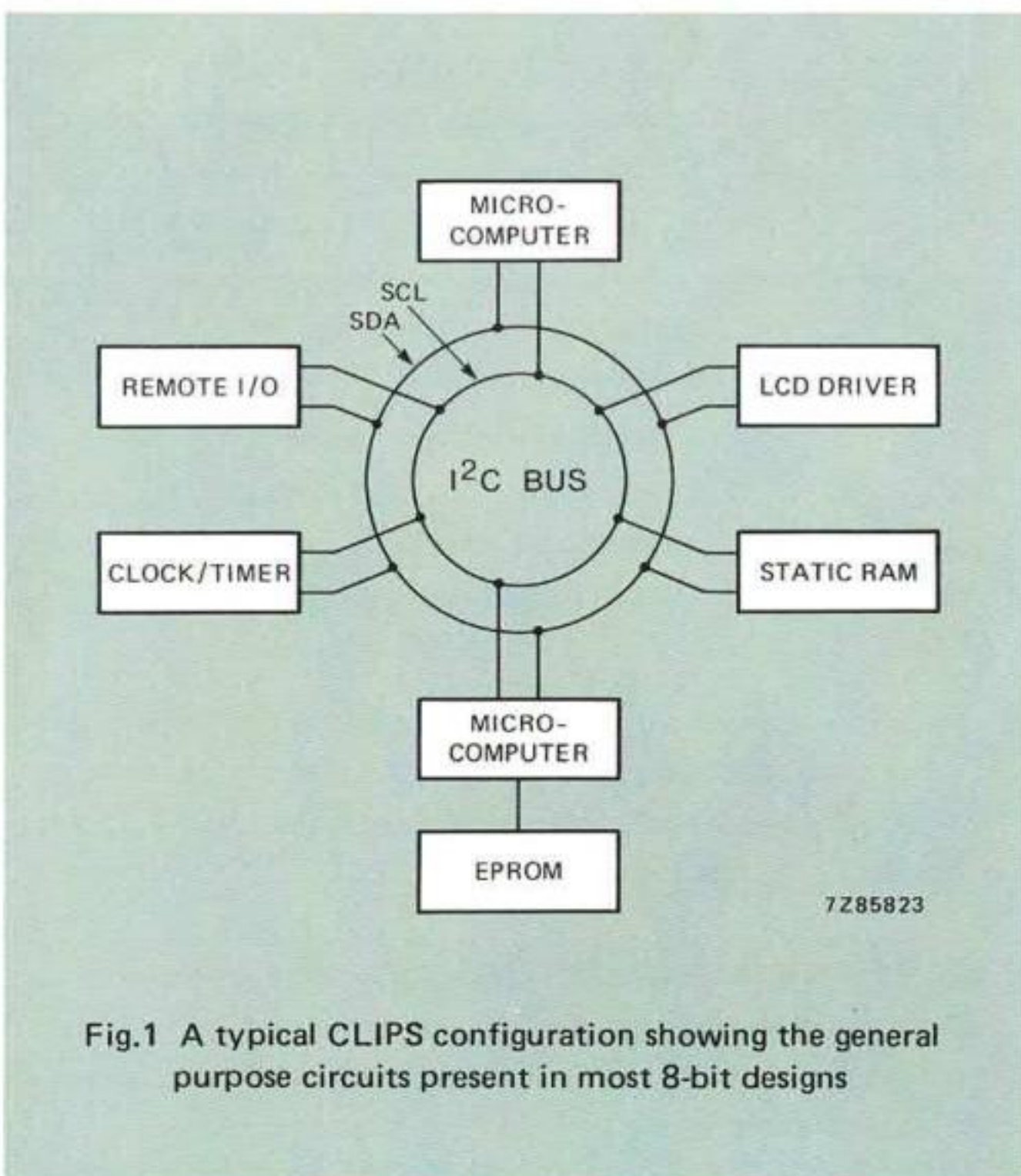


Fig.1 A typical CLIPS configuration showing the general purpose circuits present in most 8-bit designs

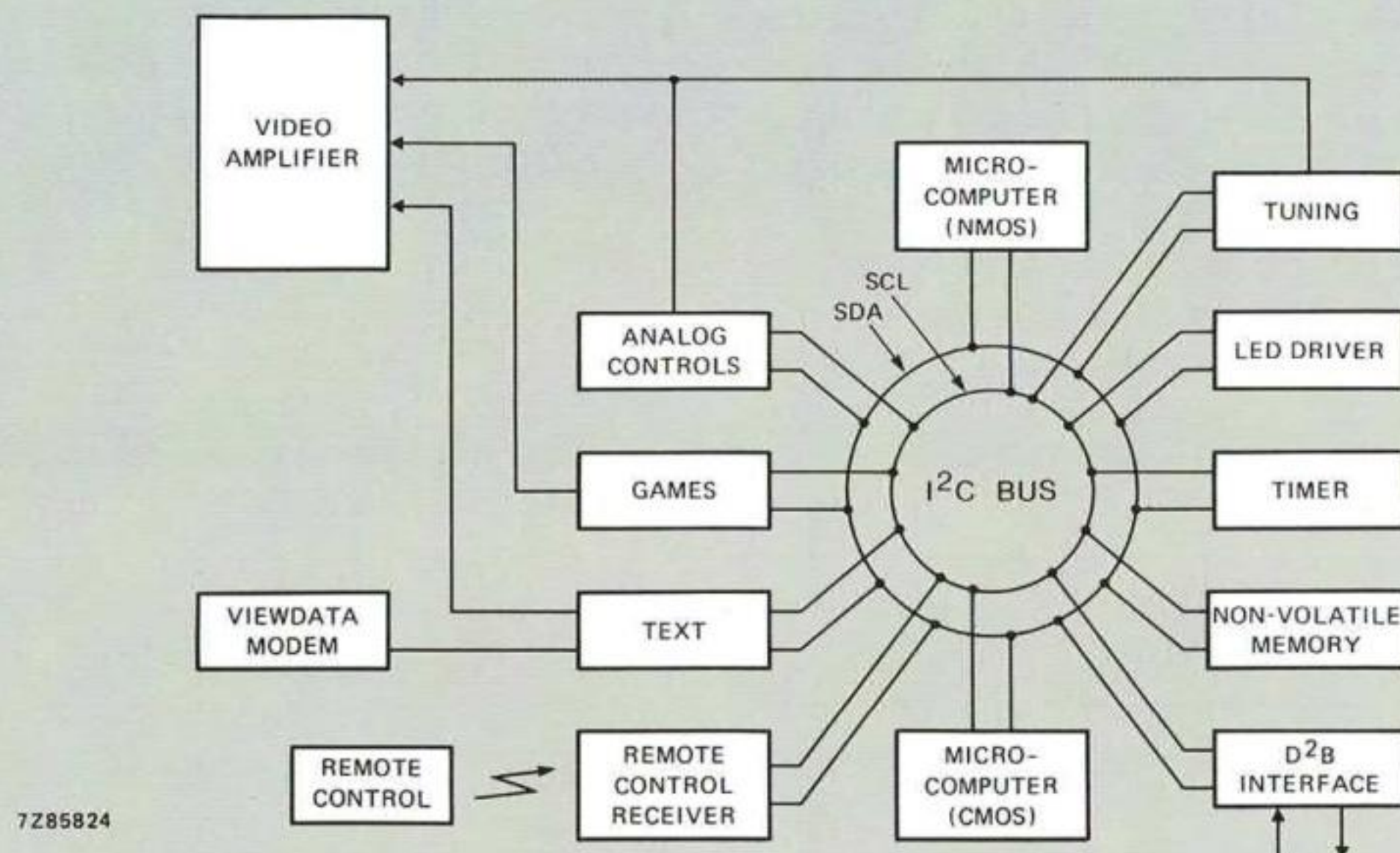


Fig.2 The many functions required for a modern tv can be easily implemented with CLIPS circuits. The specification of the interconnecting I²C bus also allows CMOS, NMOS and I²L devices to reside on the same bus

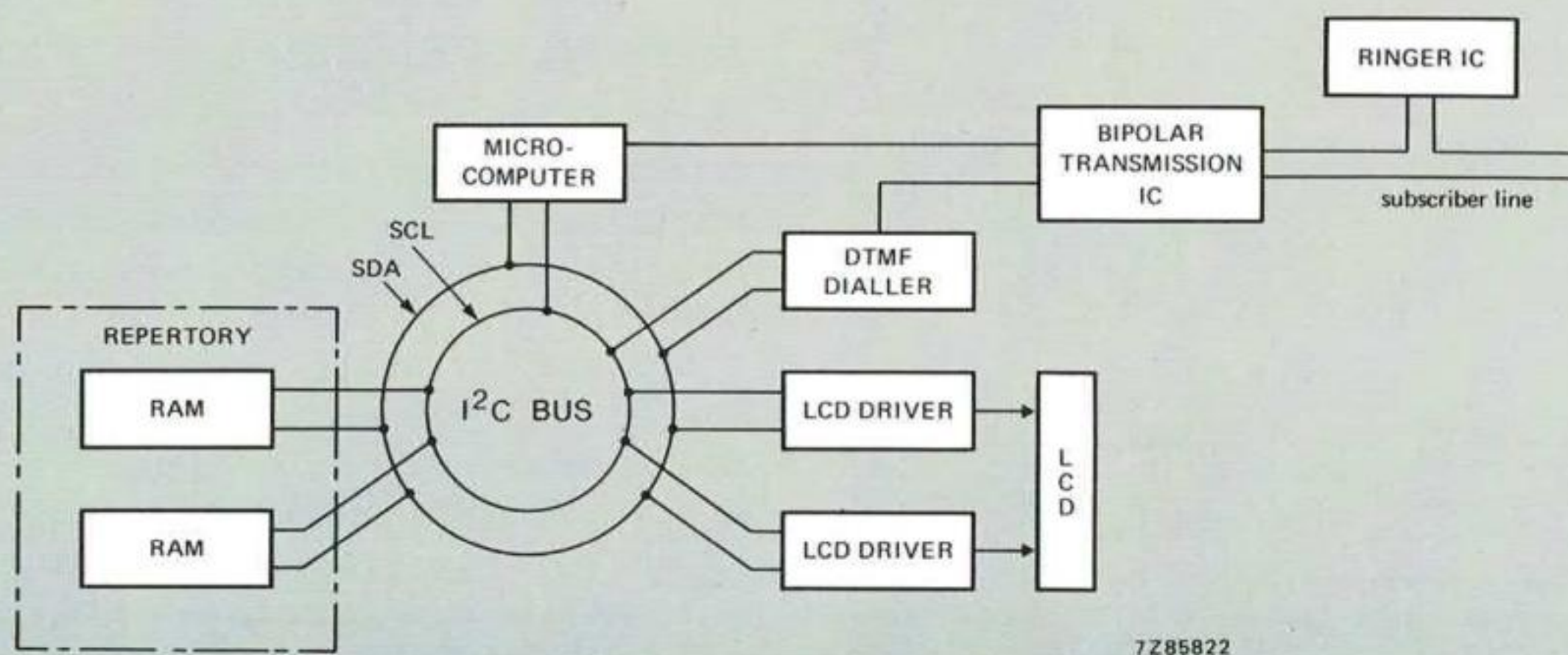


Fig.3 Telephone set is also well suited to CLIPS implementation. The additional RAM can be used to store telephone numbers for repertory dialling

on the microcomputer and can be used for such functions as repeated-call or repertory dialling. The DTMF dialler can be added whenever the local exchange converts to a tone-dialling system. The LCD and its drivers are also optional.

By providing the general-purpose devices within a telephone set, the CLIPS system gives the designer a great deal of freedom. Although the application demands that the interfacing ringer and bipolar transmission ICs are not connected directly to the I²C bus, the other devices which are can be configured to match a wide range of specifications

and demands from both telephone authorities and subscribers. We have already built-up a library of telephony-related software modules to help designers meet the various requirements they are likely to encounter.

The CLIPS concept is ideal to respond to the fragmented nature of present telephony applications. Each authority has its own requirements; each consumer has his own preference. To design a 'cover-all' telephone set is almost impossible. CLIPS offers a framework within which a designer can work effectively.

Industrial applications

In industrial environments, CLIPS systems (Fig.4) can perform a variety of functions. For intelligent machine control, level sensing, pressure monitoring – the implementation of CLIPS systems can provide distributed processing and microcomputer control on-site, where it is needed.

For analog applications, a whole range of sensors can be used. These can then be connected to an A/D converter to provide data for devices connected to the I²C bus. Keyboard encoding circuitry provides user-access to the system, with user-output sent via the display driver. For control purposes, evaluated data can be fed back to actuators such as temperature controls or electromechanical switches via another D/A converter.

For digital applications, data can be sent or received via remote I/O circuits. Due to the nature of the I²C bus, remote I/Os can be situated anywhere within the control environment; other CLIPS circuits can likewise be placed exactly where they will best perform their allotted task. Within a cabinet, wiring can therefore be drastically reduced. Instead of trailing parallel wires between devices, remote I/Os can be used to convert the parallel device output into serial bus input almost immediately – saving space, saving wire, and making life much easier for the service engineer. The remote I/O, for example, would be connected near simple on/off devices: to drive valves or relays, activate emergency sirens, or read keys and drive LEDs.

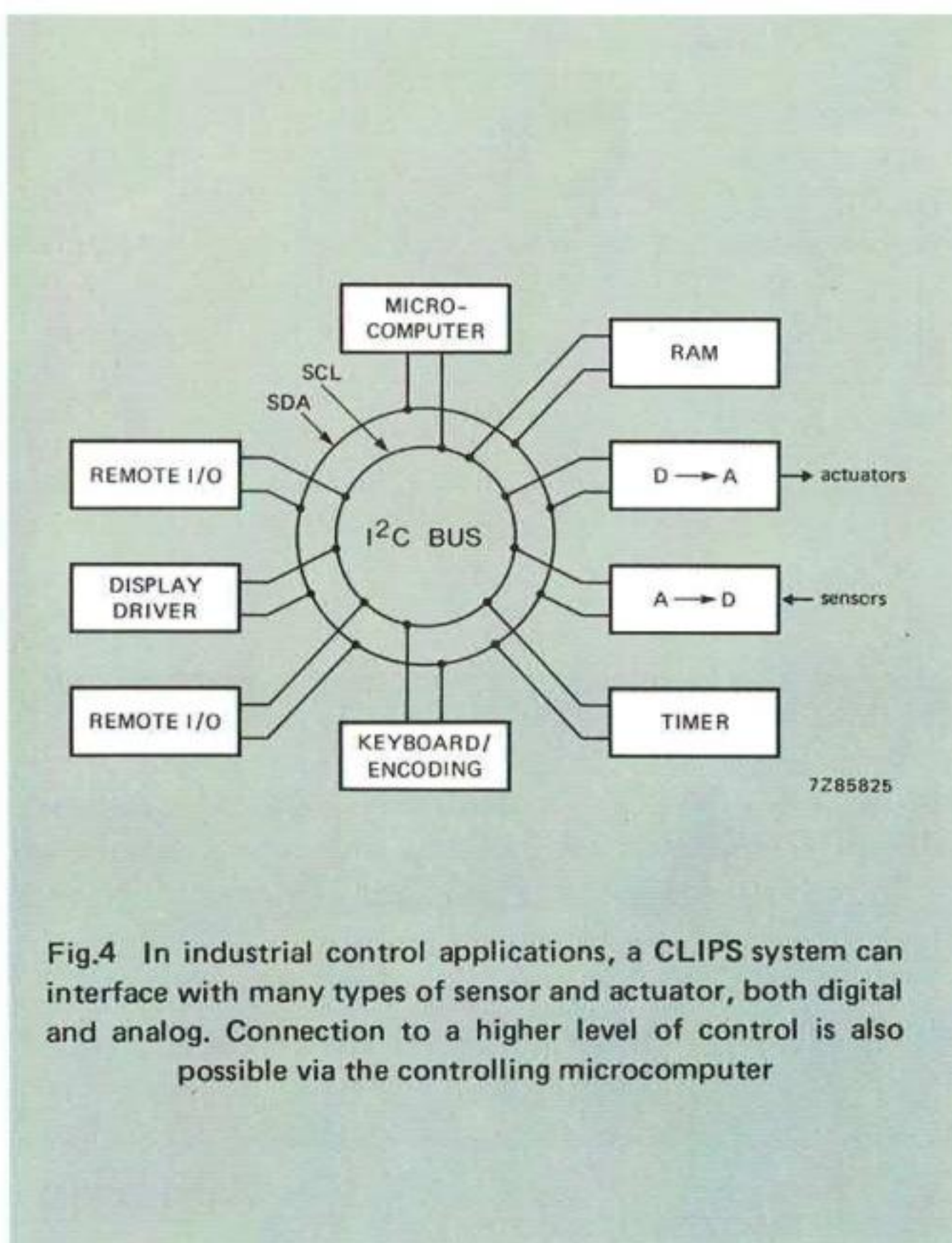


Fig.4 In industrial control applications, a CLIPS system can interface with many types of sensor and actuator, both digital and analog. Connection to a higher level of control is also possible via the controlling microcomputer

When used in an industrial environment, CLIPS systems can also be connected to higher levels of control, using the parallel ports of the microcontroller for example. A CLIPS system can therefore cover the complete range of industrial applications from hand-held, battery-powered measuring instruments to the first stage of a large scale process control system.

For low-volume Industrial designs, piggy-back versions of both the NMOS MAB8400 and CMOS PCF8500 single-chip microcomputers can be used. By connecting industry-standard EPROMs to these devices, designers can still build systems using CLIPS ICs.

CLIPS ICs – THE BUILDING BLOCKS

The previous examples highlight the CLIPS philosophy – general-purpose devices complemented by application-specific peripherals. By examining some CLIPS ICs in more detail, the interfacing simplicity of CLIPS circuits will also become apparent.

Static CMOS RAM (1024 bit)

The PCD8571 static CMOS RAM incorporates an interface for direct connection to the I²C bus. Its low data retention voltage (min 1.0 V) and low standby current (typ. 50 nA) make this memory suitable for numerous CLIPS applications.

In addition to acting as a general-purpose RAM expansion for CLIPS microcomputers, the PCD8571 can also find service as a more dedicated device. In the telephony application (Fig.3), for example, it can provide the extra RAM to store telephone numbers for repertory dialling. In radio or TV, it can be used to store channel presets.

Three hardware address pins are included on the PCD8571 to extend the specific device address. Up to 8 of these RAMs can be connected to the I²C bus, allowing the amount of memory used and its eventual purpose to rest with the designer.

Auto-increment for memory word addresses also facilitates efficient write/read of blocks of data; for example, channel preset information in a tv application would usually require 2 consecutive data bytes.

When connected to the I²C bus, the PCD8571 acts as a slave transceiver. Figure 5 takes us through the READ and WRITE modes associated with transfers to and from a master device. To ensure that a transfer occurs, data is sent in groups of 8-bits accompanied by an acknowledge bit, with failure to acknowledge a byte transfer resulting in the transfer being terminated by the master device.

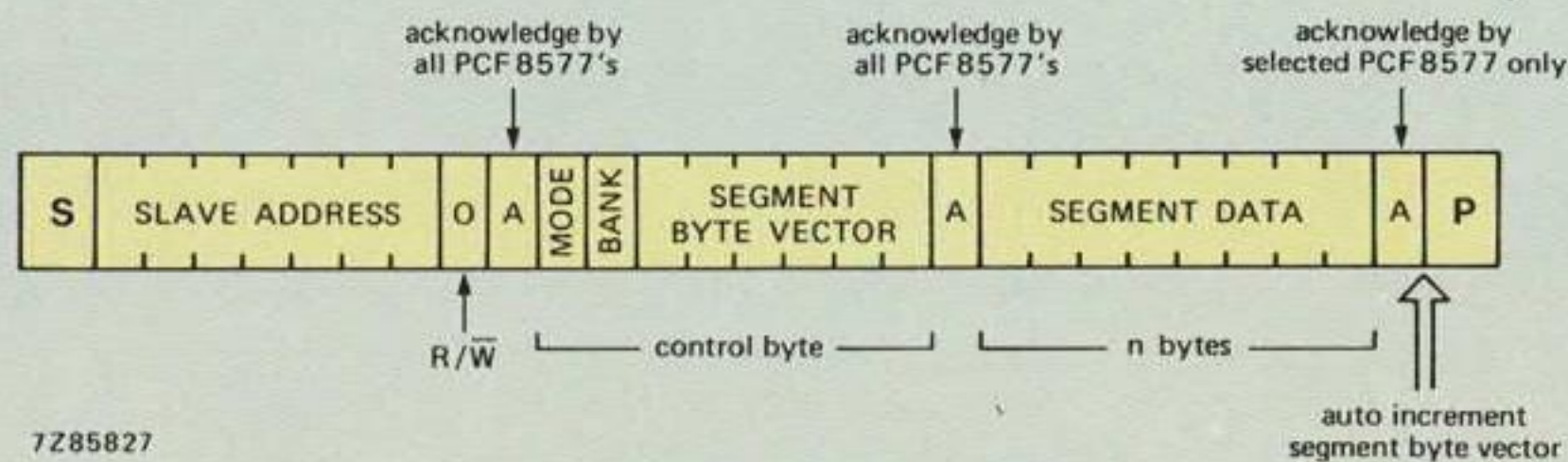


Fig.6 The bus protocol for the PCF8577 LCD driver. After acknowledging the slave address, the second control byte indicates which device is selected and the display mode of that device

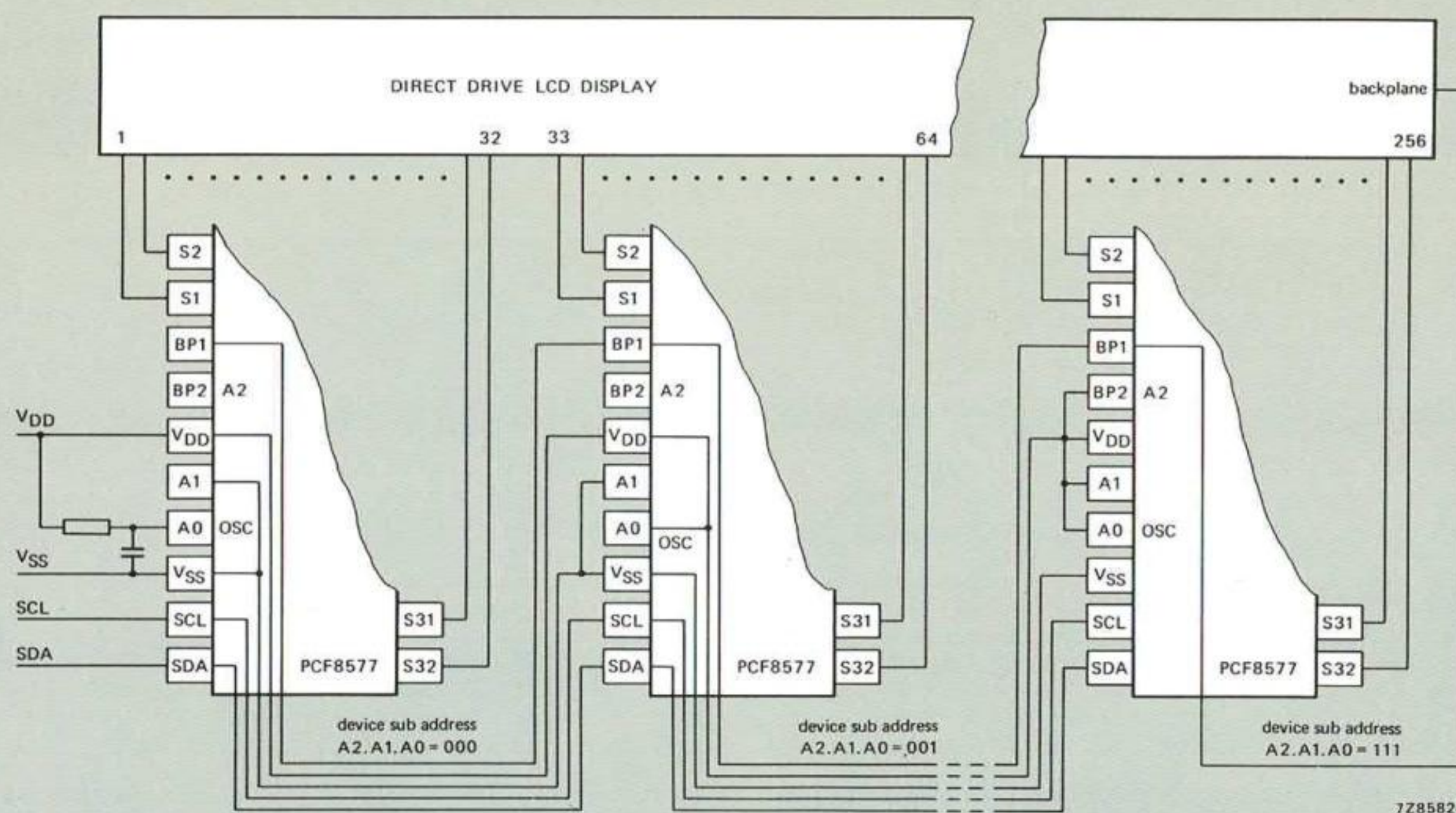


Fig.7 In direct drive applications, expansion to a 256 segment display is possible using 8 PCF8577 units

After each segment byte is loaded, the SBV is incremented automatically. In this way, sequential loading occurs when more than one segment byte is received in a data transfer. The control register also includes two display control bits, MODE and BANK. The MODE bit selects either direct drive or duplex; the BANK bit allows switching between two alternative control stores when the device is in the direct drive mode.

The programmable addressing of the PCF8577 allows the number of LCD drivers connected to a CLIPS system to be increased to a maximum of 8 directly driven units (4 duplex), giving 256 display segments (Fig.7). Therefore, the type of display output can be tailored to suit each member of a product range.

Remote 8-bit I/O

As shown in the industrial control example, remote I/Os within a CLIPS system can act as an interface between the I²C bus and a digital source. The PCF8574 is an 8-bit I/O circuit. It consists of an 8-bit quasi-bidirectional port and an I²C interface. This device can also interface microcomputers without a serial interface to the I²C bus (as a slave function only). The PCF8574 has low current consumption and includes latched outputs with high current drive capability for directly driving LEDs.

The PCF8574 differs from the other CLIPS circuits already described in that it possesses an interrupt line (INT). This line is connected to the interrupt logic of the microcomputer on the I²C bus. By sending an interrupt signal on this line, the remote I/O can inform the microcomputer if

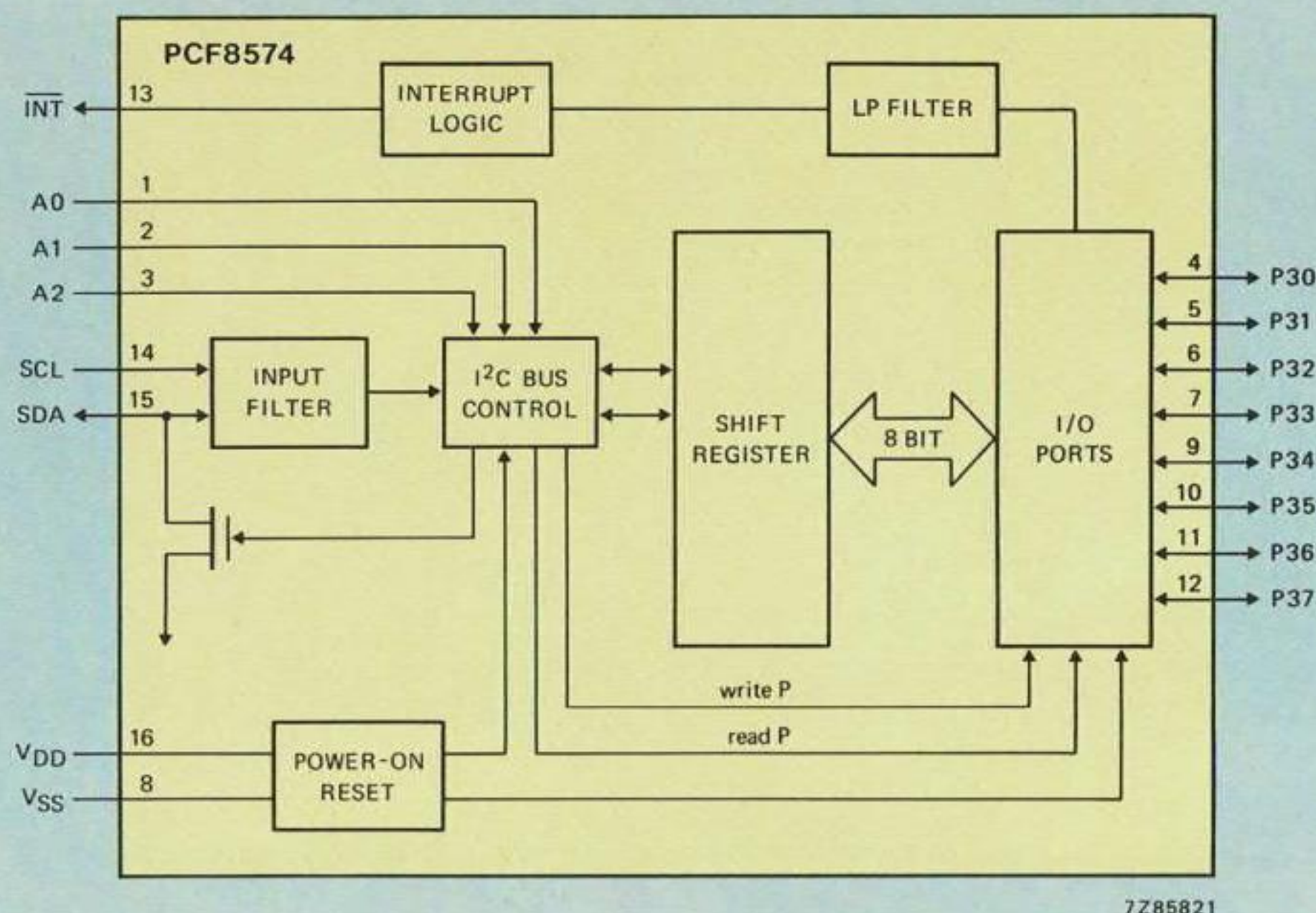


Fig.8 Block diagram of the PCF8574. Note the Interrupt Latch which informs the micro-computer of data on the I/O ports. The microcomputer can then access the expander in the READ mode, via the I²C bus

there is incoming data on its ports without having to communicate via the I²C bus. This means that the PCF8574 can remain a simple slave device (Fig.8).

CLIPS – GENERAL PURPOSE AND DEDICATED ICs

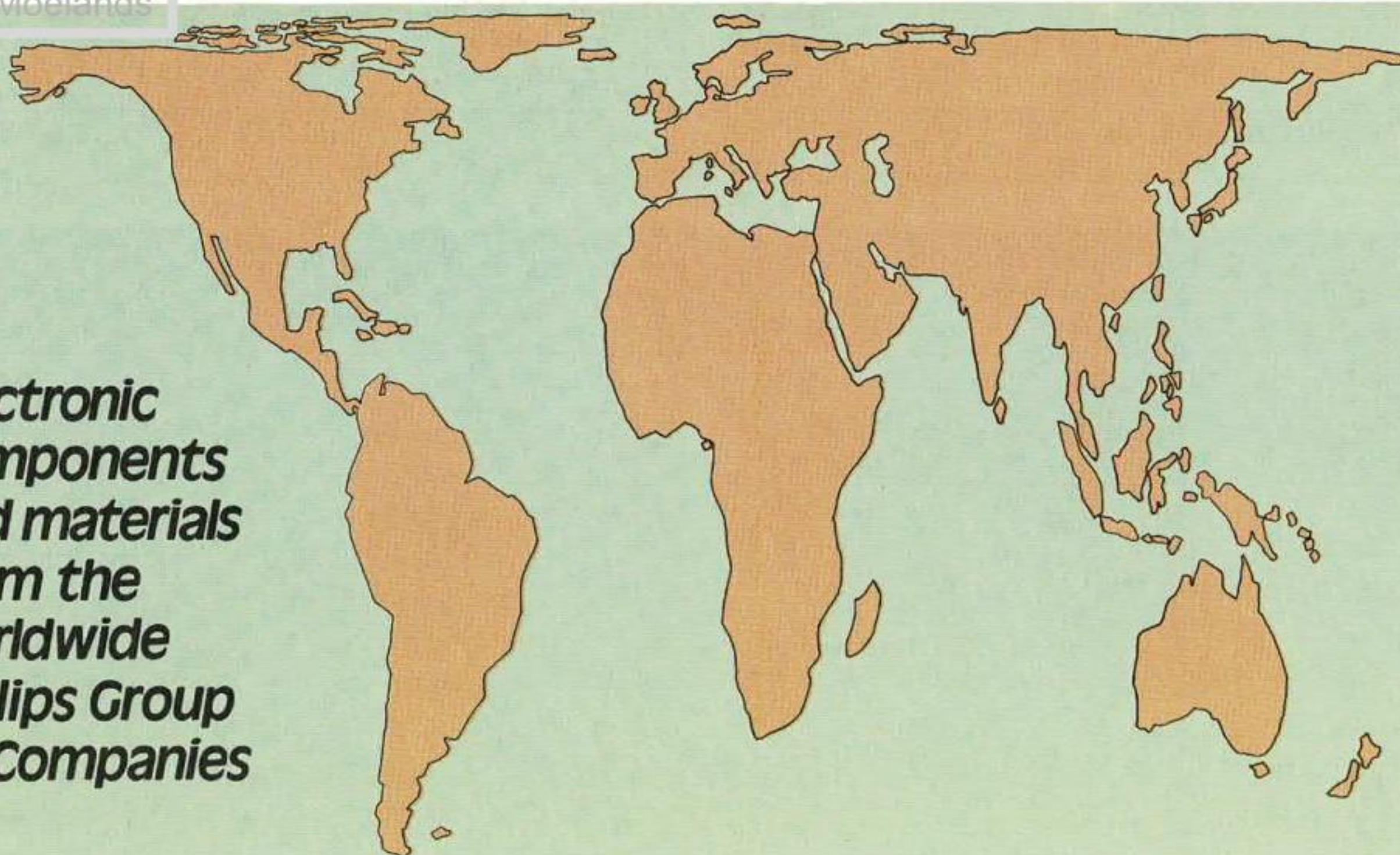
The devices described are some of the general-purpose CLIPS ICs; more of these types of circuit are available. This selection is meant to serve only as an example of the types of function, addressing schemes and read/write actions

of devices within a CLIPS system. The dedicated blocks mentioned in the various application examples are also, or soon will become, readily available.

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