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COST-EFFECTIVE TECHNIQUES FOR MINICOMPUTER DATA ENTRY AND SYSTEM STATUS DISPLAY

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Synopsis

The paper describes the hardware and software design of two mini-computer peripheral devices which have been developed to provide keyboard data entry and system status monitor facilities at very low cost.

For numeric data entry, a method is described by which popular mass-produced hand-held or desk calculators based on an MOS LSI circuit can be interfaced to a computer. The necessary signals are taken from the multiplexed segment and digit enable outputs of the calculator chip, and the normal arithmetic, memory, number base conversion or function features of the calculator are unimpaired.

For system status display, a monitor is described which uses an alphanumeric plasma-panel operated in a continuously cycling mode analogous to that of news agency annunciators. This allows a small display panel to present status messages of length restricted only by the size of the computer memory buffer which they are allocated. The cyclic display buffer driver allows the numerical information embedded in the status messages to be continually updated, and automatically selects fault or status messages for presentation in accordance with a priority structure which inhibits the redundant display of inclusive conditions.

1 Introduction

In electronic experiments at the European Organization for Nuclear Research (CERN), on-line minicomputers are used to execute a number of simultaneous and inter-communicating tasks. CAMAC data acquisition, experiment control and sample event monitoring, for example, may be combined with digital video-tape system control[(1)], special hardware processor operation and satellite computer link-handling. While the minicomputers are equipped with a conventional CRT data terminal with keyboard, additional low-cost data-entry and display facilities are desirable to permit convenient multi-operator communication with the different levels of software activity and dispersion of the locations from which they can be controlled.

This paper describes two techniques intended to fulfil these requirements at minimum cost. For numeric data entry, a method is described by which popular mass-produced hand-held or desk calculators based on an MOS LSI circuit can be interfaced to a computer. The necessary signals are taken from the multiplexed segment and digit enable outputs of the calculator chip, and the normal arithmetic, memory, number base conversion or function features of the calculator are unimpaired.

For system status display, an alphanumeric plasma-panel is operated in a continuously cycling mode analogous to that of news agency annunciators. This technique allows an inexpensive small display panel to present status messages of length restricted only by the size of the computer memory buffer which they are allocated.

2 Numeric data-entry station

MOS LSI technology combined with high-volume production techniques, justified by a competitive consumer market exceeding 1 million units/month, result in the popular electronic calculator being available at a price which compares favourably with that of keyboard/

display devices destined solely for professional computer applications.

2.1 Calculator chip

The computer interface is designed to operate with calculators based on a popular family of array logic circuits[2]. Many variations of this calculator chip have been produced, different functional characteristics being obtained by single-level gate mask programming, limited only by the size of the ROM program, the RAM storage and the control, timing and output decoders. Since the timing and output decoders of the chip are custom programmable, and the calculator manufacturer also has some freedom in his choice of power supply arrangements and other implementation details, it cannot be assumed that all calculators employing members of this series can be interfaced without some minor modification. On the other hand, a number of calculators employing other electronics can also be interfaced by the technique described.

It is assumed that the only outputs available from the calculator are cyclically-scanned digit and segment enable lines, driven by open-drain MOS buffers, coded for driving a multiplexed array of 7 or augmented-7 segment cold cathode gas discharge, fluorescent or LED numeric indicators. The digit-enable outputs, which are also used to interrogate the keyboard matrix, decimal point selector and mode switches, are always positive-true. However, the polarity of the segment outputs can be programmed, and in the case of liquid crystal displays may be negative, requiring the addition of supplementary inverters. The nominal calculator clock frequency is in the vicinity of 250 kHz.

While inexpensive calculators can normally be used in floating-fixed or full-floating mode, and exceptionally some models may have more than 8 digits, all data transferred to the computer are interpreted by the interface as positive 8-digit (binary, octal or decimal at software option) integers. The calculator is therefore normally operated in floating fixed mode with the decimal point position selected at the rightmost end. In this mode keyboard-entered data are displayed full-floating but the result is normalised after any operation.

2.2 Calculator modifications

As the available free space within most desk calculators is rather limited, and a pocket calculator is even more densely packaged, the number of components to be added is restricted to a minimum. The 0v reference is assumed to be the drain supply, with nominal substrate and gate voltages of +7.2v and -7.2v respectively.

The 8 digit-enable and 5 (used) segment outputs of the calculator chip are buffered by the addition of two integrated circuits each comprising an array of 8 protected high-gain Darlington pairs intended for driving common-cathode multiplexed LEDs. These inverters add negligible loading to the calculator signal lines, do not require use of the calculator power supply, and have a high sink current capability permitting an adequate cable length to the computer.

In addition, an extra keyboard momentary-contact switch is required to generate an interrupt requesting that the data displayed be read by the computer. Finally, a single LED is added to the keyboard, to be energised momentarilly on computer acceptance of each data entry.

2.3 Computer interface

The computer interface converts the digit-serial 7-segment coded data from the calculator to 32-bit BCD format for input to the computer. The principle of operation of the interface is indicated in Fig. 1.

Inspection of the redundancies of 7 or augmented-7 segment codes for decimal digits shows that most selections of only 5 segments are sufficient to define each digit uniquely. Transcoders from 7-segment code to decimal have been described by Lambert[3] and Southway[4], and these could be employed in conjunction with a 10-line to 4-line priority

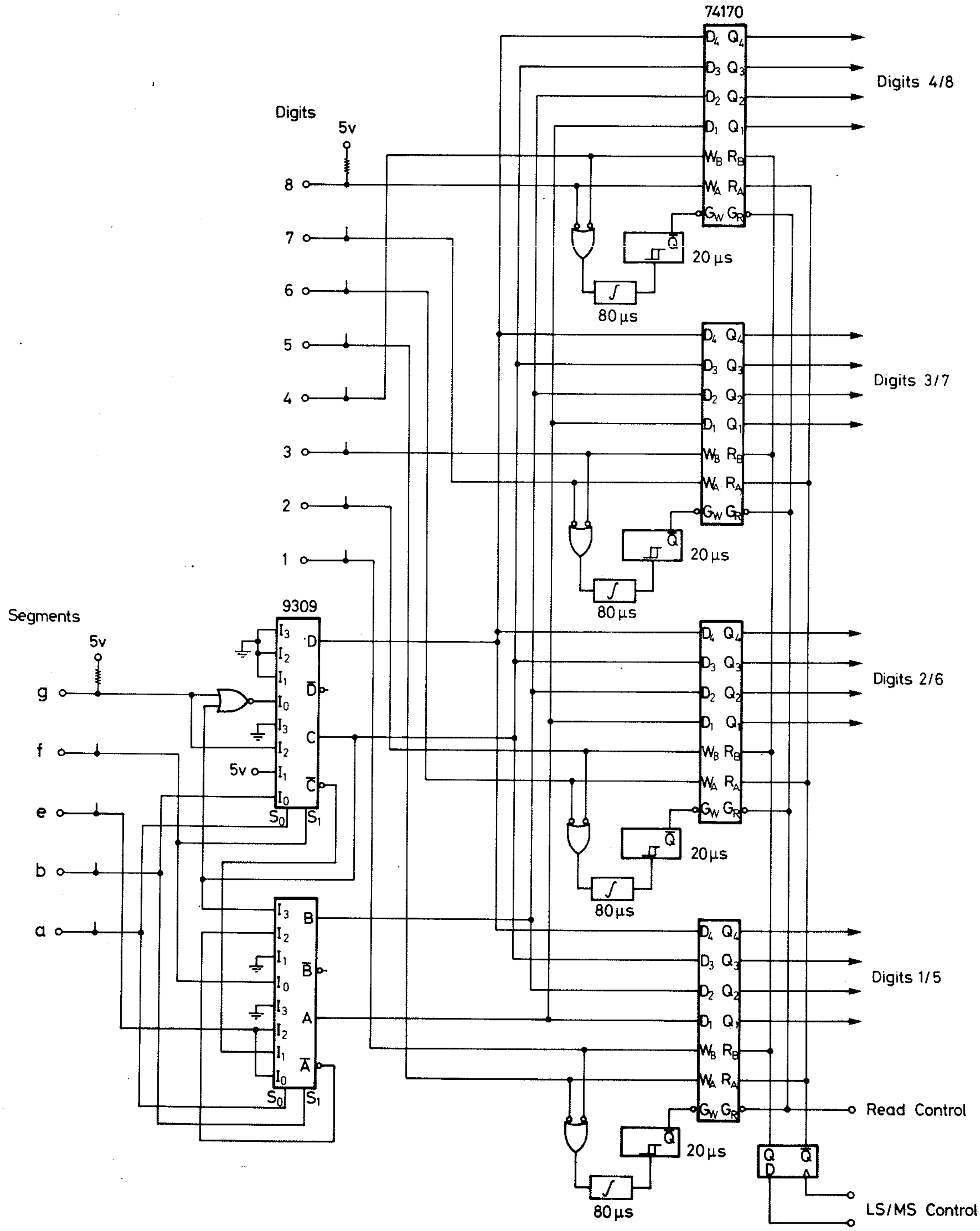

Fig. 1

Principle of computer interface

encoder. The alternative method utilized accomplishes the transcoding with two dual 4-input multiplexers with true and complement outputs[5] The transcoder operates on segments a, b, e, f and g, and accommodates the usual variations in font for numerals 4, 6, 7 and 9 which may be programmed by different calculator manufacturers. As the calculator segments are multiplexed, so the transcoder outputs scan through the codes for the 8 digits in MS to LS sequence.

The 8 calculator digit-enable lines are used to select locations (addresses 01, 10) in four 4 × 4-bit MSI register files at which the BCD codes for each digit are stored, memory write signals being generated nominally 100 μs after each digit is selected. Most versions of the calculator chip are programmed with no segment blanking and leading and trailing digit blanking of 3 clock cycles (1/13 of a digit time). However, versions used with some gas discharge displays may have 3 or 6 cycle inter-segment blanking and others used only with LEDs may have no inter-digit blanking. By interleaving the digit data in the register files, the interface is designed to accept these variants without modification of the simple clocking arrangements.

The 32-bit transcode of the data currently in the calculator display memory is thus continuously available in the interface registers. Normally the calculator is read in response to a data-entry request interrupt generated by the supplementary keyboard switch. A computer output transfer is made between the two 16-bit read operations to switch the register addresses from the LS to the MS word and the response LED on the calculator is pulsed after the MS word is read to indicate acceptance of the data by the computer. Fig. 2 shows a realisation in the form of a calculator interface card which is housed in the I/O cage of a typical minicomputer. In this case the required interrupt input is associated with the I/O slot, and the interrupt control circuitry is also accommodated on the card.

Numeric data entered by the calculator may be interpreted as parameters which are referenced by one or more of the software tasks, or

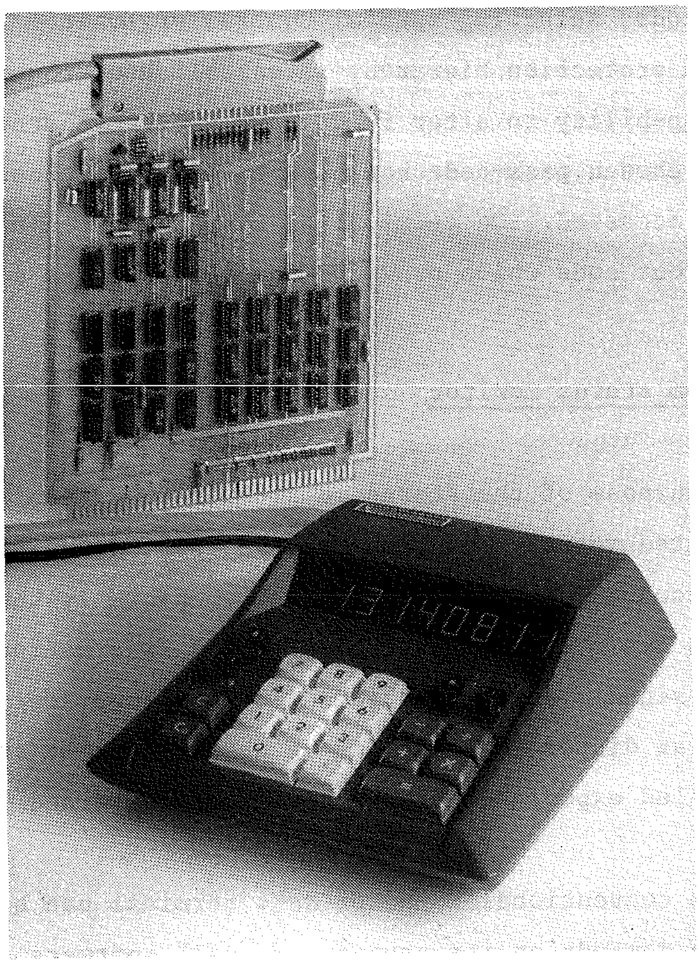

Fig. 2

Calculator data-entry station

Fig. 3

System status monitor

as function codes selecting special control or monitor programs for execution. A protection hierarchy is established around major functions having the capability to alter fundamental system characteristics, and only after a chosen pass-code has been entered can these higher level functions be accessed. On terminating such access, a pass-code operator enters a log-out code which prevents their subsequent accidental misuse.

3 System status monitor

The purpose of the status monitor is to present to the experimenter in an integrated manner a continuously updated, detailed yet easily-interpreted account of the status of the complete system during the progress of a run. The display collates the information individually presented by signal lamps, numeric indicators, register displays and error alarms at dispersed locations of the experiment and which may require detailed experience of the equipment concerned for interpretation.

While the conventional computer data terminal can be used for this function, the demands on its capacity for all software system control operations, selected data listing, command entry echoing, and graphical operations such as sample event display and histogramming, limit its availability as a continuous surveillance status monitor. In fact, where the terminal driver is under the control of the background software monitor, it is generally enabled for keyboard command entry in the quiescent state, which inhibits its use for status messages originated from foreground software tasks.

3.1 Cyclic display panel operation

The status monitor (see Fig. 3) utilizes a low-cost plasma display panel[6] with character generator, refresh logic and memory. The characters of the message travel continuously from right to left through a 32-character window provided by the display. The monitor accepts data coded in 7-bit ASCII, and for codes $040\text{-}137_8$ displays a 64-character repertoire using a 5×7 dot matrix with 2 columns of space between each character and 16 columns between words. Although messages entering the display at the right are shifted across the panel in increments of one character (rather than one column), the double space between words ensures good legibility at normal scan rates. All the remaining codes $000\text{-}037_8$ and $140\text{-}177_8$ including CR, LF, VT, HT and FF are interpreted as space, for compatibility with text strings formatted for page presentation and to ensure continuous message travel. Code 007 (Bell) also causes a momentary audio tone signal and energises the fault indicator.

The rate at which the monitor interrupts the computer for new characters is controlled by an internal oscillator which can be preset by a rear panel control for any desired reading speed. When the front panel 'search' switch is depressed, the oscillator frequency increases to a rate which causes the messages to travel rapidly through the display for the purpose of scanning a large file. While the 'hold' switch is depressed, message motion and the computer conversation are interrupted to allow displayed numerical data to be studied. The data message scan is independent of the column-scanning refresh rate of 85 Hz. Typical preferred viewing rates are found to be - Normal monitoring: 5 char/sec, Search: 50 char/sec.

To ensure a constant rate of message travel in spite of a computer interrupt response time which is subject to the variable duration of higher priority interrupt service, each new character is entered to the display panel in coincidence with the monitor's periodic interrupt request for further data, rather than at the time it is output by the computer. However, if the computer has failed to output a character in response to the previous interrupt, further shifting is inhibited so that the last message remains displayed if the computer halts. In the case of a real-time operating system which is already based on a repetitive interrupt generator, the status monitor driver may alternatively be called from the main interrupt handler. In this case the display shift times are of course restricted to multiples of the main interrupt source period, but the local search facility remains operative if the interrupt rate exceeds about 20 Hz.

3.2 Status monitor driver

The monitor is supplied with messages by a general purpose cyclic buffer driver running in the associated minicomputer. On each monitor interrupt, the driver executes wholly or partially one or more commands from a variable-length table of control macros. Where a macro specifies a character string to be displayed, it is executed repeatedly on subsequent interrupts until an end-of-string character is encountered. Macros may also be calls to subroutines which fetch and convert updated numerical parameters, advance the control table pointer to the first character string output macro to follow, and commence its execution. The referenced subroutines may also modify the control table pointer conditionally on system flags.

In this way the numerical information embedded in the status messages is continually updated, and fault or status messages are automatically selected for presentation in accordance with a priority structure which inhibits the redundant display of inclusive conditions. It has also been found useful to include in the macro table a reference to a general character string buffer which can be loaded with operator messages from the system console.

4 References

1 CITTOLIN, S., and TAYLOR, B.G., 1976, Proc. IERE Conf. on Video and Data Recording, Birmingham, 99-110.

2 TI Engineering Staff, 1973, 'TMC 0100 NC MOS/LSI One-Chip Calculator Series for Design Engineers', Texas Instruments Inc., Dallas, Texas, USA.

3 LAMBERT, J., 1974, Electronics, 47, No. 16, 105-106.

4 SOUTHWAY, J., 1974, Electronics, 47, No. 24, 113.

5 Fairchild Engineering Staff, 1974, Electronic Engineering, 46, No. 559, 12-13.

6 Burroughs Corporation, 1974, 'Self-Scan Panel Displays', EC Division, Plainfield N.J., USA.