8031 IN-CIRCUIT EMULATOR

A previous article by the author on the 8031 microcontroller described some problems associated with developing single-chip microcontroller applications. The present article deals with the hardware that, when coupled with a PC and some software, enables the hobbyist to construct a low-cost in-circuit emulator (ICE) for the popular 8031 microcontroller.

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THE hardware is based on the Dallas DS5000 family of processor. It has an 8031 architecture with battery-backed static RAM replacing the internal ROM. The actual processor is the Dallas DS2250, which is a SIP stick version of the DS5000. Functionally, the DS5000 and the DS2250 are identical. The DS2250, however, uses lower cost packaging techniques.

The hardware design is simple and constitutes the minimum required to build an operating DS2250 board. Consequently, it is a general-purpose software development board that will be used as an ICE.

Circuit description of the ICE

The circuit diagram in Fig. 1 shows that the clock for the DS2250 (IC1) is generated with the aid of an 11.0592 MHz quartz crystal. The frequency of the crystal may be familiar to those constructors who have previously built MCS-51-based (8031, 8052, 8751) computer boards with RS-232 port hardware. The frequency of the quartz crystal is a multiple of the bit rate on the serial port, i.e., 11.0592 MHz divided by the bit rate is an integer. This particular crystal enables the higher bit rates (19.2 KBit/s) to be generated. If a clock frequency of 12 MHz were chosen, the timers would be able to count intervals aligned more accurately to 1 s, but the user would be restricted to a maximum serial port speed of 4,800 baud.

Depending on its position, link J1 on the board allows the user to use the crystal on the ICE board, or that on the target board. If a link is installed between pins 1–3 and 2–4, the ICE crystal is used. If link positions 3–5 and 4–6 are selected, the crystal in the target system is used.

All of the pins on the DS2250 are connected to a 40-pin DIL socket, US1, which is positioned at the underside of the PCB. The board can be inserted directly into the 8031DIL socket on the target board. The processor can be powered either from the target board (power supplies on pin 40 (+5 V) and pin 20 (ground) of the DIL socket, or via header PL1. The power applied to header PL1 is 5 V on pin 2, and 0 V on pins 1 and/or 4. If the supply connector is accidentally reversed, no harm should come to the ICE.

Communications, initialization and downloading of software is provided via the RS-232 port on the PC. As the ICE51 uses a single 5-V supply, a combined RS-232 buffer/voltage converter is required. The device selected was the MAX232 (IC2) from Maxim. Four 10 µF capacitors, C4 to C7, are required for the voltage converter on board the MAX232. The RS-232 specification states that the high and low voltages must be more positive than +3 V and more negative than −3 V respectively. These voltages are provided by the MAX232 with typical values of +9 V and −9 V. A serial cable attached to PL2 connects the ICE51 and the PC serial port (PL2 is a 7×2 IDC connector). The 14-way connector was selected so that either a 9-way (AT-style) or a 25-way (XT-style) D-connector can be fitted at the PC end. Jumper J3 determines which D-type is in use. For an XT-style RS-232 connector, install links 7–6, 5–4 and 3–2. For an AT-style RS-232 connector, install links 7–8, 1–2 and 3–4.

Link J2 determines the source of the digital stream for the serial port to the receive pin on the processor. If J2 is connected in position 2–3, the data stream comes from the 8031 DIL header. In position 1–2, the data stream is connected to the output of the MAX232.

Downloading code to the ICE

The DS2250 has two modes of operation. The first mode executes code on reset from internal ROM. This ROM contains a small bootstrap loader program which is primarily designed to download code into the battery-backed RAM. Other operations include setting the memory configuration register, initialising the security keys and locking the RAM. To enter bootstrap mode, the $\overline{\text{PSEN}}$ line must be held low when the RST (reset) line is pulled high. The DS2250 then monitors the serial port, waiting for a 'carriage return' code, ASCII character 13. This operation is used to initialize the serial port baud rate. Thus, the sequence of actions to load a program into the DS2250 is:

Table 1. DS2250 register configurations

PA3	PA2	PA1	PA0	Partition Address
0	0	0	0	0000H
0	0	0	1	0800H
0	0	1	0	1000H
0	0	1	1	1800H
0	1	0	0	2000H
0	1	0	1	2800H
0	0	1	0	3000H
0	1	1	1	3800H
1	0	0	0	4000H
1	0	0	1	4800H
1	0	1	0	5000H
1	0	1	1	5800H
1	1	0	0	6000H
1	1	0	1	6800H
1	1	1	0	7000H
1	1	1	1	8000H

mcon register:

D7	D6	D5	D4	D3	D2	D1	D0
PA3	PA2	PA1	PA0	RA32	ECE2	PAA	SL

RA32 = embedded RAM size: 0 = 8 KByte; 1 = 32 KByte
ECE2 = enable second RAM chip (normally set to 0)
PAA = partition address access
SL = security lock

(1). Use a terminal emulator such as Procomm, or the ICE51 software.
(2). Toggle the reset switch, ensuring that it finishes in the 'on' position.
(3). Press the return key — the Dallas loader copyright message should then appear. You are now on line with the ICE.
(4). Unlock the external RAM using the 'U' command.
(5). Read the contents of the RAM configuration table by pressing 'R'. The configura-

tion value after executing the 'U' command will be hexadecimal value F8. This register is used to define the size of the RAM available on the DS2250. Currently, the DS2250 supports three RAM sizes: 8 KBytes, 32 KBytes and 64 KBytes. The configuration register also determines the partitioning of the internal RAM into program and/or data memory. The internal RAM can be configured as data memory, program memory or split into part data and part program. The only constraint is that the RAM can not be both program and data memory within the same address range.

Table 1 describes the configuration permutations. When the ICE software is used, the memory configuration is normally set to $E8, which means that at least 2 KBytes of RAM from $7000 to $7FFF is configured as data memory, while RAM from $0000 to $6FFF is configured as program memory. **(6).** To write to the configuration register, use command 'W E8'.

The default setting for the 32-KByte ICE51 is hex E8. The partition address divides the battery-backed RAM into program memory (below the partition address) and data memory (above the partition address).

A program in Intel-hex format can now be loaded into the internal program memory. For instance, to load the ICE monitor program with the aid of the ICE51 host software, enter the load command, i.e., at the DOS prompt enter

DALLAS <CR>	Start the ICE51 software.
VDU <CR>	Enter terminal emulation mode. Set ICE51 switch on.
<CR>	Set the baud rate for the ICE51. Response should be the Dallas loader prompt.
L <CR>	Download Intel-hex format file.
<PgDn>	Enter the file name to download.
DALLAS.OBJ <CR>	File name. Set the ICE51 switch S2 to off. Micro AMPS copyright message should appear.
<ESC>	Return to the host software; the monitor is now running.

Alternatively any terminal emulator, such as Procomm, that supports ASCII file transfers can be used.

At this point the monitor program has been downloaded, and the DS2250 has been configured correctly. To start executing the user code, switch S2 is set to 'off', and the user program will start executing from address $0000 as if the code had been masked in the internal ROM. The advantages of using internal ROM-ed code is that all four parallel ports are available for user applications. Two and a half of these ports would normally be required for the address, data and control bus when the processor executes in expanded mode.

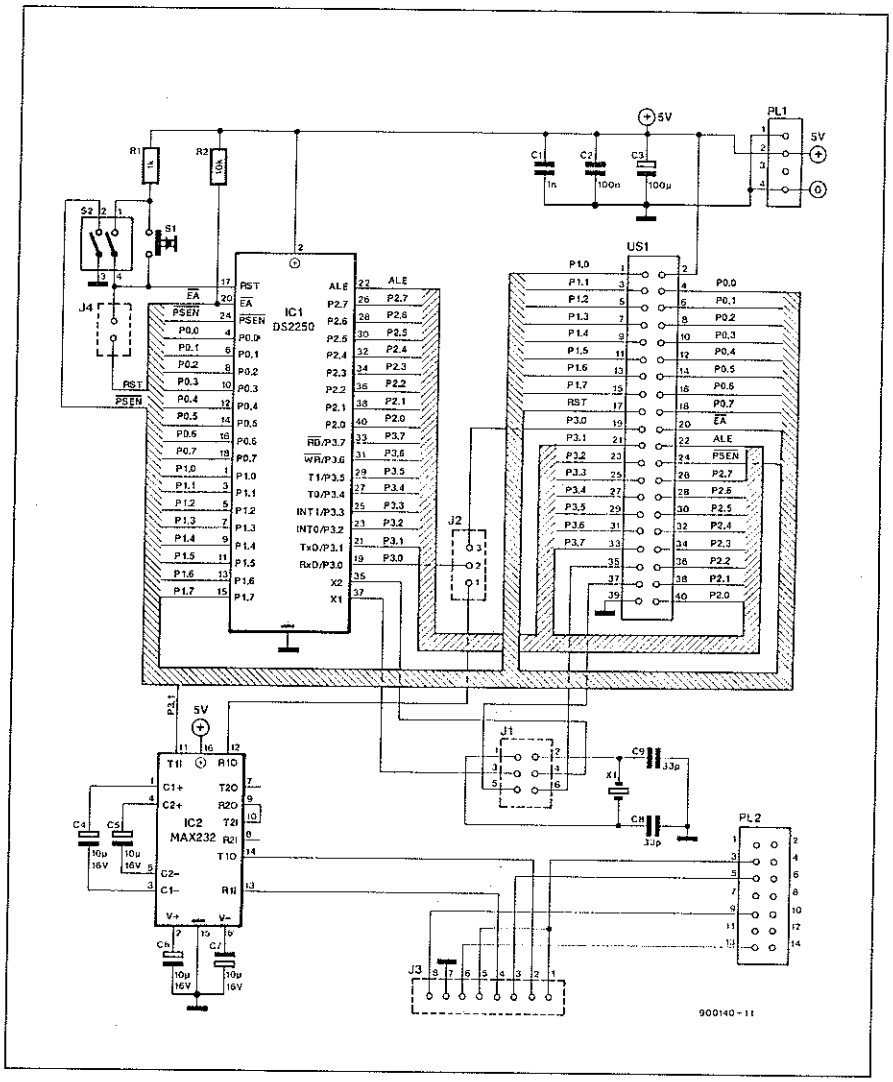

Fig. 1. Circuit diagram of the 8031 In-Circuit Emulator (ICE). Connector US1 is plugged into the socket for the 8031 in the target system. Software downloading is accomplished by means of a serial link to a PC running a terminal emulation program.

The ICE51 software package

The ICE51 software, which is available from Micro AMPS, provides debugging tools to convert the board from a DS2250 evaluation board into a full-blown single-chip mode 8031 in-circuit emulator. The 2 Kbytes large resident program is loaded into the DS2250 starting at address $0000 up to $07FF. User applications can then be loaded from $0800 onwards. The interrupt vectors are shifted by an amount of $800, i.e.,

Interrupt	Old	New
Ext. INT 0	$3	LJMP $803
Timer 0 overflow	$B	LJMP $80B
Ext. INT 1	$13	LJMP $813
etc.		

The software provides tools for reading and writing to internal and external memory, loading and saving Intel-hex code, reading and writing to the special function registers, disassembling code, starting programs, managing up to 10 breakpoints, and single-step operation through programs. ■

Note:
The hardware and software described in this article are available from Micro AMPS Ltd. • 66 Smithbrook Kilns • Cranleigh • Surrey GU6 8JJ • ENGLAND. Telephone: (0483) 505395. Fax: (0483) 268397. The author is joint managing director of Micro AMPS Ltd.

Reference:
"The 8031/8751 microcontroller", *Elektor Electronics* July/August 1990.