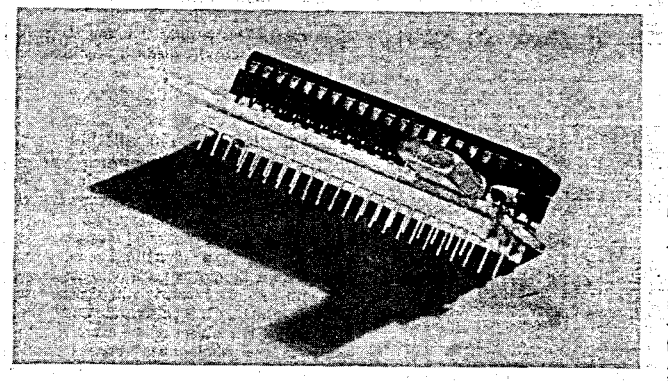
from the 6502 to the 6809



a new 'super' 6502! The 6809.

As always in the ever advancing world of electronics a popular and worthwhile microprocessor, has been superseded once again by a chip with a greatly improved performance: the 6809 CPU, manufactured by Motorola.

The beauty of the 6809 is that it can be implanted into existing 6502 systems without any difficulty, thereby creating a new 'super' 6502. With just a few minor hardware modifications, constructors will then have at their disposal a much faster, more powerful computer with new fascinating programming facilities.

Following the latest trend in high-speed systems, Motorola has developed a microprocessor that has an internal 16-bit structure. One of the reasons why the 6809 is known as a 'Super 6502' is that its registers have the same names as those in the 6502. The features of the two systems are in fact very similar, except that the Motorola chip is much faster and more powerful. The differences in structure are shown in figure 1.

Register	6809	6502
X-Register	16 Bit	8 Bit
Y-Register	16 Bit	8 Bit
Stack Pointer	16 Bit	9 Bit
Accu A	8 Bit	8 Bit
Direct Page Reg.	variable	fixed: Page zero
Status Register	8 Bit	7 Bit
Program Counter	16 Bit	16 Bit

As can be seen, the 6809 contains an additional 8-bit accumulator and a variable 'direct page register'. The 6502 CPU, on the other hand only had a single page zero. The 6809 also makes 256 direct pages available. The 6809 has a further advantage in that its two accumulators, A and B, may be combined into a 16-bit D accumulator. The instruction set will look familiar to 6502 operators. Very little has in fact been altered in the mnemonics and addressing modes.

The branch commands are particularly effective. The processor can branch within the −16 . . . +15, −128 . . . +127, or −32768 . . . +32767 address ranges. New instructions, such as BRA (branch always) and BSR (branch to subroutine), allow programs to be stored in any area of memory, without having to rely on absolute addresses and without having to alter a single byte. Such programs are known as 'relocatable' routines. The system introduces a new addressing mode, the 'program counter relative' mode. This is extremely powerful, and enables any memory location to be addressed (at a certain moment) that corresponds to the contents of the program counter.

As the saying goes, "What you gain on the swings, you lose on the roundabout" and the same applies here, for 6502 fans will have to give up one of their favourite addressing modes, the indirect indexed mode (as in LDA-(POINT),Y, for instance). Unfortunately, indirect addressing modes cannot be indexed on the 6809. However, as we have already seen, plenty of other valuable facilities are available instead.

The indexed addressing takes a slightly different form. The opcode consists of a single byte and is followed by a 'post byte', which may contain a 5-bit displacement. The next byte or byte pair either represents an 8-bit or a 16-bit displacement in two's complement. The effective address is calculated by adding up the index and the displacement: index (contents of X, Y, S, U, A, B or C registers) + displacement = effective address.

If a displacement is made within the −16 . . . +15 range an instruction in the index addressing mode will only contain two bytes: the opcode and the post byte.

Although there is no actual indirect indexed addressing mode, memory may also be accessed indirectly in the indexed addressing mode. What happens is that the pointer (the sum of the index and the displacement) indicates the memory location in which the ADH of the effective address is stored. The ADL is stored in the following memory location: In the 6809 CPU, the ADH and ADL are always located in that order, after the operation word. But, as readers will remember, this was the other way around in the 6502 (ADL, ADH). An indirect facility is extremely useful, as it enables arrays and symbol tables to be drawn up in high-level programming languages.

The accumulators may also be used as index registers. This means not only can they be incremented and decremented, but they can also be employed during operations in arithmetic or binary (Boolean algebra). In other words, the index can be calculated. This is known as the accumulator indexed mode. The 6809 CPU contains two stack pointers, S and U, and is therefore already one up on the 6502. S is a 16-bit stack pointer with the same function as that of the 6502. Return addresses from subroutines and from machine registers are automatically stored on the S stack. It is also used to execute interrupts.

As its name suggests, the user stack pointer (U pointer) is purely at the disposal of the programmer. It is also 16 bits wide and mainly used as an input buffer and loop pointer during text editing.

When the 6809 and 6502 systems were compared at the beginning of the article, both were seen to have a fairly similar programming structure. Even the addressing modes are almost identical, the only difference being that the 6809 CPU provides a more 'powerful' instruction set and is faster than the 6502. All in all, it really is worthwhile to update the 6502 system and convert it into a 6809. What makes it even more tempting is the fact that:

- only the hardware needs to be slightly modified;
- more software is available for the 6809 CPU than for the 6502;
- BASIC, FORTRAN, PASCAL and a cross assembler (for all commercial processor types) are all provided on diskette for the 6809 system. Cross assembly may be 'bi-directional' such as, say, from the 6809 to the Z80, or vice versa;
- and there is one standard floppy disc control format for all 6809 systems, whereas various formats exist for the 6502.

But it is time to answer the question of how can a 6502 system be converted into a 6809 computer? First of all, mount the 6809 CPU together with a 4 MHz quartz crystal and two capacitors on a piece of Veroboard and mount the unit on a 40-pin DIL connector. Now simply substitute the 6502 for the 6809. The pin assignment is shown in figure 2. This piggy-back construction is illustrated in the photograph.

The conversion procedure:

- Remove the 6502 CPU from its socket.
- Insert the 6809 piggy-back board in the now empty socket.
- Replace the 6502 operating system (stored in ROMs or EPROMs) by the 6809 version. Use may be made of the ASSIST 09 monitor program, for instance, published in the Programming Manual mentioned below.

A text editor, a linker/loader and a disc operating system (DOS) are also available for the 6809, which means that the Junior Computer (in combination with a floppy disc system, of course) can now be 'taught' to run in FORTRAN and PASCAL. In the end, the machine will be completely polyglott!

Background literature:
MC 6809-MC 6809E; 8-bit Microprocessor Programming Manual; M6809 PM (AD); 1.3.1981; Motorola (including ASSIST 09)
Macro Assemblers Reference Manual; 6800, 6801, 6805, 6809; M68 MASR (D); Motorola.

1

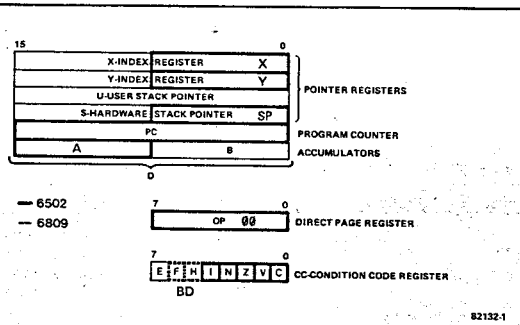


Figure 1. A comparison of memory organisation in the 6809 and the 6502.

2

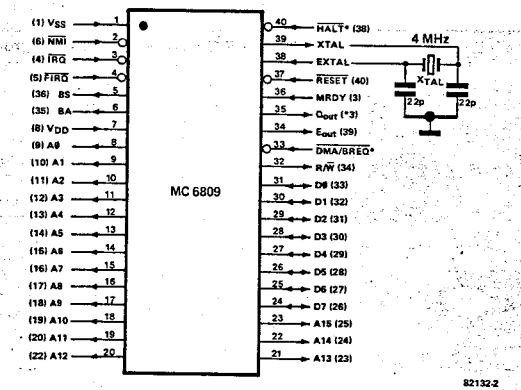


Figure 2. Pin assignment of the 6809 CPU. The pin numbers in brackets correspond to the 6502.

1

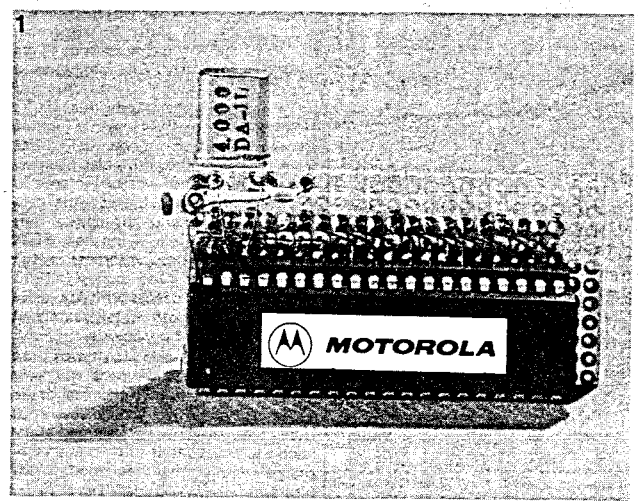


Photo 1. How to construct the piggy-back board for the 6502 socket. The new CPU board is mounted on a 40-pin DIL connector.