Part II

Scorpion

Motor Control Instructions

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Last month, I presented an overview of the Scorpion design parameters and language commands. The following article describes the basic motor control instructions in detail.

The 8K byte EPROM provided with each Scorpion contains the complete Scorpion operating system. The software only uses approximately 4K bytes of the available EPROM leaving room for expansion. This operating system provides instructions for controlling all aspects of the Scorpion hardware.

Drive Motors. Drive motor control is designed to reduce the overhead on the host computer. The speed to be maintained by each motor and the motor direction are transmitted to the Scorpion to start the two drive motors. The controlling computer does not have to control the individual steps. Once the movement command has been issued, it will continue to move until another motor speed command is issued, a microswitch on one of the motors is activated, the reset button is pressed, or the system reset command is sent to the onboard computer.

Speed Control. Motor speed is controlled by a movement pulse which is sent to each motor at a designated frequency. The frequency is determined by a countdown timer. The Scorpion uses one timer on each of the 6522s to control a motor. Motor direction is changed by altering the count in each timer.

Each timer contains a 16-bit register that can contain a number from 0 to 65535. This number is decremented at the clock rate. Since the Scorpion's system clock operates at 920 kHz, the maximum value of 65535 would cause the counter to reach zero 14 times per second. Since this is too fast for the motors, we use a control subroutine to step the motors once for every 14 times the counter reaches zero. Every time the motor is actually stepped, the subroutine updates the motor movement counter.

Motor speed is changed by altering the count in the 6522 counter. The lower the count, the higher the motor speed. There is a limit to how fast you can toggle the stepper motor. The stepper motors we use should not be stepped more than 200 times per second. This would produce approximately 250 revolutions per minute (4.17 revolutions per second) at the drive motors and 42 revolutions per minute at the wheel after the 6-to-1 reduction. These numbers translate into a 49 feet per minute maximum speed.

The motor control instruction is nine bytes long. A typical instruction, such as "/7M+23+35," is interpreted as follows:

- "/" indicates the following information is an instruction.
- "7" indicates 7 data bytes to follow.
- "M" indicates a motor move.
- "+" indicates the motor direction for the left motor.
- "23" indicates the speed for the left motor.
- "+" indicates the direction for the right motor.
- "35" indicates the speed for the right motor.

Each motor has 99 speeds in each direction. The computer converts the speed requested to the proper count for the timers. Speed 00 is valid; it turns off the motor.

One step on a drive motor moves the Scorpion 0.0491 inches. A five-byte movement counter allows the computer to track a distance of up to ±9999 moves. This is equivalent to 40 feet.

Optical Scanner. The three instructions for controlling the optical scanner are Reset, Move, and Scan. Individual instructions exist for the horizontal and vertical axes.

Before we can move the optical scanner intelligently, we must know our starting position. The Reset instruction returns the optical scanner to a known "home" position. The two Reset operations (/2HR and /2VR) are used to reset the horizontal and vertical axis.

The Reset instruction starts the scanner moving towards a "home" position. The scanner moves 240 steps in the counter-clockwise direction. Since each axis of the optical scanner has a stop, and there are only 240 steps per axis, this procedure guarantees that the scanner stalls against the stop. Once the scanner is positioned against the stop, the Reset instruction moves the scanner back 120 steps. This places the optical scanner in a forward-looking position.

The Move instruction produces motion relative to the current motor position. A command such as "/5HM-03" instructs the horizontal motor to move 3 steps in the counter-clockwise direction. "/5HM+03" would move the motor three steps in the clockwise direction. Corresponding commands are available for controlling the vertical axis, simply substitute "V" for "H" in the commands.

The Scan instruction moves the optical scanner through a defined number of horizontal or vertical steps. A typical instruction, "/4HS15" is interpreted as follows:

- "/4" indicates a four-byte command.
- "H" indicates the horizontal scanner.
- "S" indicates a scan request.
- "15" the last two digits define the scan extent.

The scan extent value is interpreted as the number of steps to either side of the current scanner position through which the scanner moves. A value of 15 indicates that the scanner should move 15 steps counterclockwise and read a brightness value. The scanner then steps clockwise reading a brightness value at each step. The scanner continues to collect brightness information for $15 \times 2 + 1$ steps. Note that a scan of 1 produces three brightness values. A scan of zero produces a single brightness value.

Vertical scans are performed in a similar manner to horizontal scans. The vertical Scan instruction substitutes the letter "V" for "H."

Additional Controls. The Scorpion system also has the ability to turn two LED "eyes" on and off, generate sounds through an onboard speaker, and track a path on the ground.

The eye control instruction has only four variations. "/2E0" turns both eyes off, "/2E1" turns on the right eye, "/2E2" turns on the left eye, and "/2E3" turns on both eyes.

The onboard speaker is controlled through two parameters, frequency and duration. The command model is "/5Sffdd."

- "/5S" indicates a five-byte speaker command.
- "ff" = a two-byte frequency value. 00 indicates no tone. Frequencies from 1 to 48 provide four octaves from 117 cps to 1760 cps (A# below low C to A above high C). Frequencies from 60 to 99 are defined by the user.
- "dd" = a two-byte duration value. Durations vary from 0 to 2.5 seconds for values from 00 to 99. □

Next month. The concluding section of this article describes the second half of the instruction set and describes how the Scorpion control language can be extended with custom instructions.

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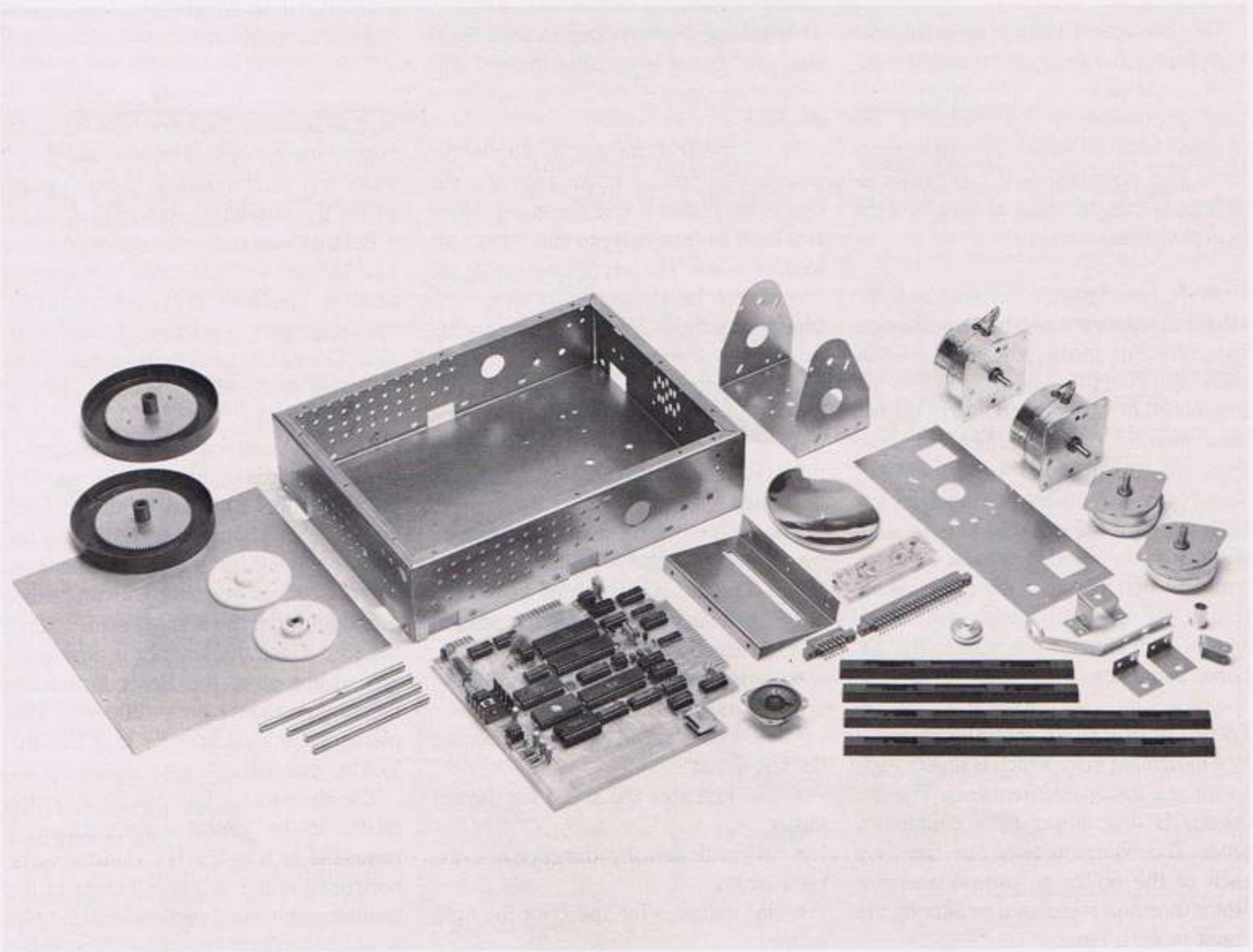

Photo 1. MAJOR COMPONENTS. Included among the major components of the Scorpion are the main drive wheels, cover plate, gears, axles, chassis, controller card, speaker, scanner reflector, bumpers, and other parts. Various small items such as screws, nuts and bolts, and microswitches, are not shown here but are also included in the kit.