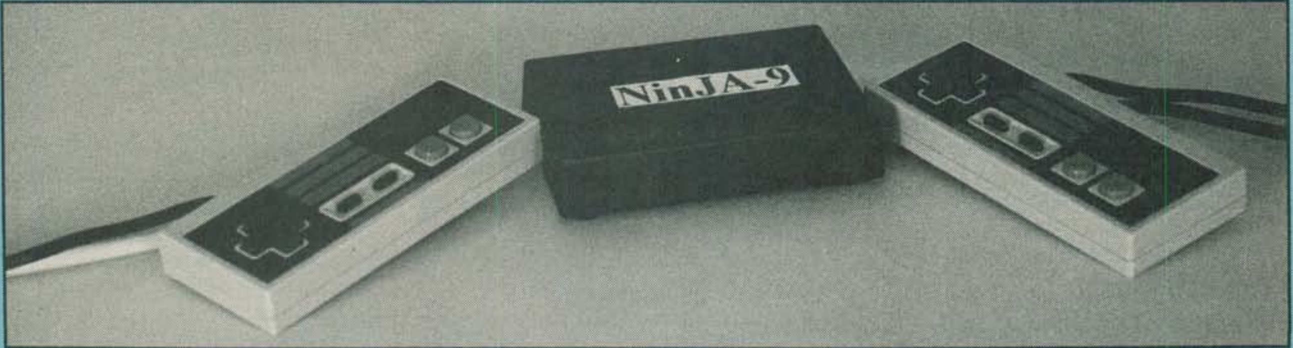

Build a Joystick Adapter

Give that old Nintendo joystick a new lease on life with an adapter that makes it compatible with your computer's game port

BY LARRY L. CAMERON

I am 24-years old, and I love frosted flakes. And like millions of adults who don't take themselves too seriously, I would like to add that I enjoy playing a good action-filled computer game from time-to-time as well.

Nothing beats the feeling I get from eliminating a bunch of bad guys or saving the Federation from destruction. For those sessions, a joystick is a must, but lately my computer-compatible joystick has been giving me trouble. Sometimes the game character would stop dead in its tracks only to be blasted to bits. Something had to be done about that old clunker of a joystick.

I looked around for a new joystick, but the ones that caught my eye were too expensive or did not seem to be responsive enough to suit my tastes. If only I could use my faithful Nintendo joystick with games on my computer! I was used to playing games with it; it had nifty features (such as rapid-fire); and it responded quicker than my old PC joystick ever did. If only it could be adapted for use with my computer.

The *Nintendo Joystick Adapter* (*NinJA* for short) described in this article is a circuit that is designed to interface your computer to many different Nintendo Entertainment System ("NES") joysticks that until recently would only work with NES equipment. If you do not own any Nintendo joysticks, perhaps you might reconsider purchasing one. Many offer slick features such as variable/multi-speed rapid fire, infrared-remote operation, and right- or left-handed control, etc.

Compatibility. There are two versions of the NinJA: one, the NinJA-15, is designed for compatibility with all IBM PC/XT/AT/386/486 and compatible computers equipped with a 15-pin game port; the NinJA-9 version is compatible with Atari-style 9-pin game ports for use with computers such as the Commodore Amiga and Atari ST.

The NinJA (referring to both versions) is compatible with all NES-style joysticks whether manufactured by Nintendo or available through a third-party supplier. On the negative side, gadgets such as the Nintendo "Zapper Gun," are functionally different than joysticks and will not be NinJA compatible. There are also several third-party joysticks that support features like "pause" and "slow motion," which are achieved by digitally manipulating the START and SELECT buttons on the Nintendo joystick. Those features do not translate to an equivalent function on your computer. In addition, joysticks designed for use with the Super NES are not compatible with NinJA1.

The NinJA-9 is completely compatible with all software that accepts joystick input on computers like the Commodore Amiga and Atari ST. In fact, the NinJA-9 allows you to use Nintendo joysticks on the whole group of computers that conform to the "standard" Atari-style, 9-pin male connector including the Commodore 64, VIC-20, Atari 800, etc., and it's even compatible with the old Atari VCS video game!

It should not come as any big surprise that the compatibility issue is much more complicated for the NinJA-15, and its interface with the IBM PC computer, since the IBM joystick is directionally analog while the Nintendo joystick is digital. In a nutshell, the NinJA-15 will work with games and programs that expect threshold-joystick input. "Threshold" refers to a software-defined analog-joystick-input value that would have to be met or exceeded by a typical IBM analog joystick to begin screen movement at a constant rate. Once that threshold is met or exceeded, movement begins.

That concept is better described than defined: if you move an analog joystick one quarter way to the left, your screen character will not move in a game that arbitrarily defines "left" to be a maximum stick deflection to the left; so screen character movement begins only with the analog joystick handle moved completely to the left. The NinJA-15 overcomes that problem by generating a relative "maximum/minimum" analog signal for each of the eight (N, S, E, W, NE, NW, SE, and SW) directions.

On the downside, compatibility with all IBM software that accepts joystick input cannot be guaranteed.

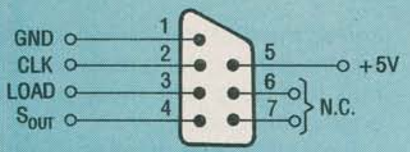

Fig. 1. Here is a pinout diagram of the Nintendo-joystick connector.

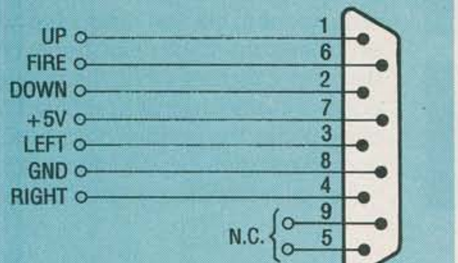

Fig. 2. This is a pinout diagram giving the signals associated with an the Atari-style joystick connector. That joystick, which was first popularized with the introduction of the Atari VCS video-game system some years ago, is digital in nature.

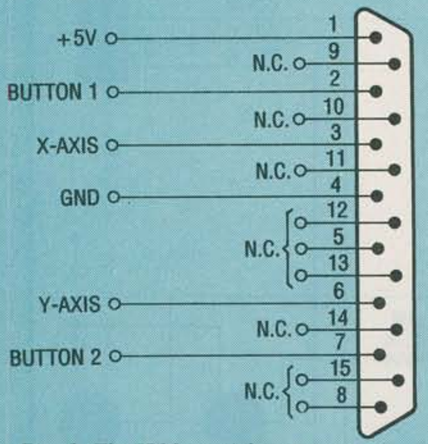

Fig. 3. The IBM joystick port uses a female DB-15 connector; the pinout and relevant signal descriptions for that connect are shown here.

PARTS LIST FOR THE NINTENDO JOYSTICK ADAPTER

SEMICONDUCTORS

U1—74HC595 high-speed CMOS 8-bit latched shift register, integrated circuit
U2—74HC190 high-speed CMOS synchronous decade counter/divider, integrated circuit
U3—LM7555 CMOS oscillator/timer, integrated circuit
Q1, Q2—2N4403 PNP transistors or equivalent (see text)
D1–D4—1N914 or equivalent general-purpose silicon diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—5,600-ohm
R2—120,000-ohm
R3, R5, R6—2200-ohm
R4—330-ohm
R7—47,000-ohm × 4, 8-pin SIP resistor array

CAPACITORS

C1, C2—0.1-μF, ceramic-disc
C3, C4—1.0-μF, 16-WVDC, tantalum
C5—0.01-μF, ceramic-disc
C6—0.001-μF, ceramic-disc
C7, C8—47-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

PL1—DB-9 female (NinJA-9) or DB-15 male connector (NinJA-15), see text
PL2—Male NES connector with cable
Printed-circuit materials, enclosure (Serpac model 031), IC sockets, wire, solder, hardware, etc.

Note: The following items are available from Larry L. Cameron (7020 Grand Canyon #243, Austin TX 78752; Tel. 512- 467-9532): the NinJA printed-circuit board for $5.00; NinJA kit including printed-circuit board and all components (excluding cables) for $10; NinJA kit including printed-circuit board, all components, and cables for $15.00; Completely assembled NinJA (specify NinJA-9 or NinJA-15) for $20.00. Texas residents, please add appropriate sales tax. Please add $2.00 for shipping to all orders.

While most available games operate by way of threshold input and will, therefore be compatible with NinJA-15, software expecting analog (linear, non-threshold) joystick input will not operate properly with the NinJA-15. An example of that is a flight simulator in which the rate of turn of the airplane is dictated by how far the joystick moves to the left or right.

PC and Nintendo Joysticks. The Nintendo joystick is a very simple digital device that consists of a 4021 CMOS parallel-in/serial-out shift register, with eight pulled-up SPST momentary switches connected to its parallel inputs. The Nintendo computer provides the necessary clock and parallel-load signals to the shift register when the joystick is connected. Figure 1 is a functional pinout diagram of the Nintendo-joystick connector.

Figure 2 is a functional pinout diagram of the Atari-style joystick connector. That joystick—first popularized with the introduction of the Atari VCS video-game system some years ago—is also digital in nature. It was adopted by Commodore and Atari for use with their home-computer systems and is still supported today in their line of Amiga and ST computers. The joystick itself consists of five normally open, SPST momentary-contact switches—four for the cardinal directions and one for "fire"—which (connected through the computer's male DB-9 joystick port) go to ground when thrown.

The IBM PC joystick, which is part analog and part digital, consists of two potentiometers (which are used to indicate the linear X-Y position of the joystick handle) and two normally open SPST momentary contact switches (which are used as "fire" buttons); like the Atari-style joystick, they too are grounded upon switch actuation. A female DB-15 connector on the computer is used for the physical connection of the joystick to the PC and is usually provided on the motherboard or via a bus-expansion card such as a dedicated game card or multi-I/O card.

Figure 3 is a pinout diagram of the IBM DB-15 joystick connector showing the arrangement and signal descriptions of relevance to the NinJA-15.

Theory of Operation. Figure 4 is a schematic diagram of the NinJA, which consists of a serial-to-latched-parallel data interface that allows a Nintendo joystick to emulate Atari-style joysticks. For IBM-style joysticks, additional digital-to-analog circuitry is included to synthesize the necessary analog directional signals.

The NinJA supplies power, ground, a clock signal, and parallel-load signals to the Nintendo joystick (which are normally provided by the Nintendo game system) to make the joystick functional outside of its intended NES connection. Since the NinJA draws

TABLE 1—NINJA TO COMPUTER JOYSTICK CONNECTIONS

	DB9	connect to →	PL1
NinJA-9	Pin 1	Up	Pin 6
	Pin 2	Down	Pin 8
	Pin 3	Left	Pin 4
	Pin 4	Right	Pin 7
	Pin 6	Button A	Pin 3
	Pin 7	V_{CC} (+5V)	Pin 2
	Pin 8	GND	Pin 1
	DB15	connect to →	PL1
NinJA-15	Pin 1	V_{CC} (+5V)	Pin 2
	Pin 2	Button A	Pin 3
	Pin 3	Pot. X	Pin 10
	Pin 4	GND	Pin 1
	Pin 6	Pot. Y	Pin 9
	Pin 7	Button B	Pin 5

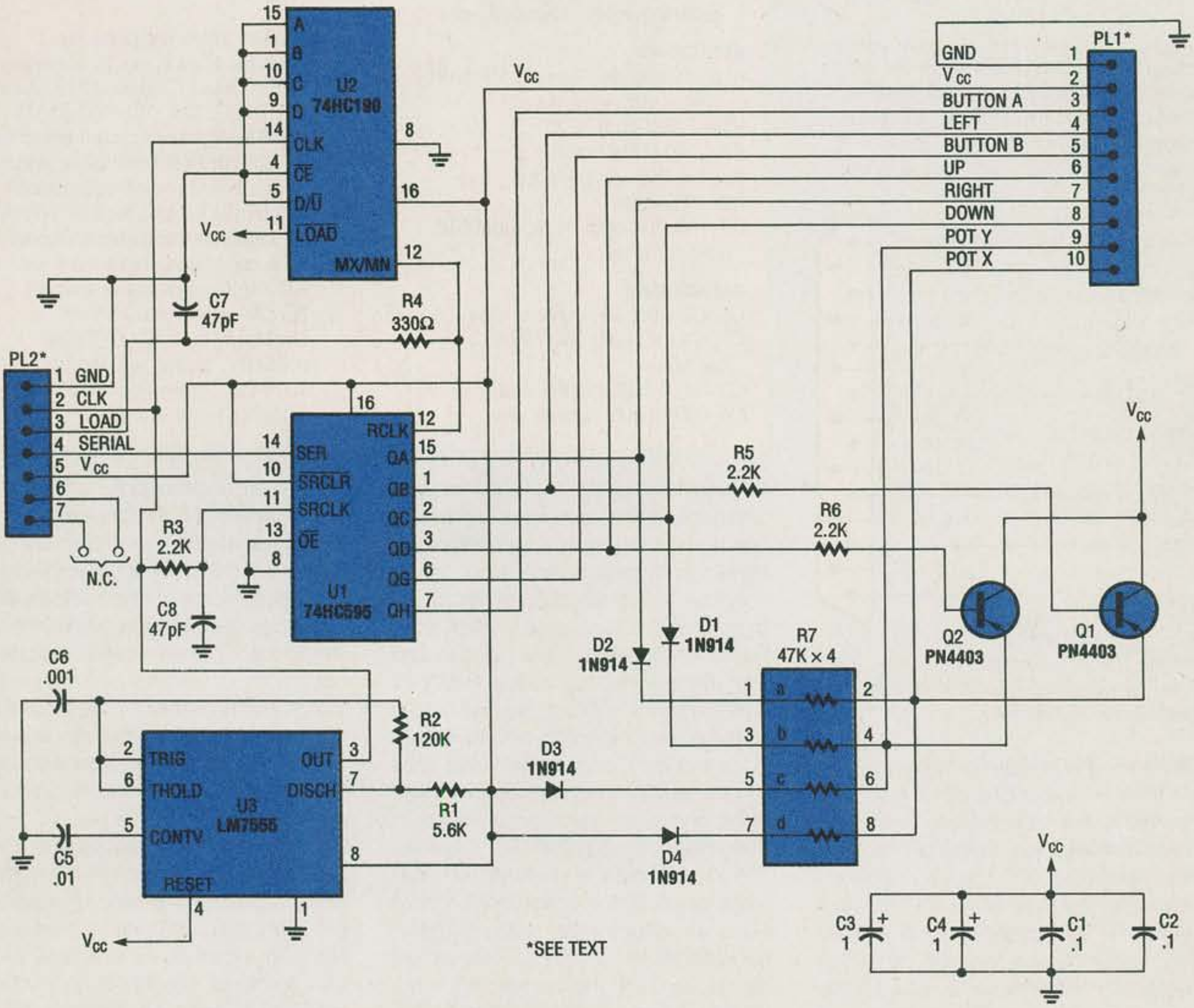

Fig. 4. The schematic diagram of the NinJA (shown here) reveals that the NinJA is fundamentally, a serial-to-latched-parallel data interface.

power from the joystick port of the computer to which it's connected, the NinJA is comprised of CMOS IC's.

A 7555 CMOS oscillator/timer (U3) is configured as an astable multivibrator, and is used to generate clock pulses with a 95% duty cycle at 10 kHz. That clock signal is routed to the CLK input of the 4021 (of the Nintendo joystick) and also to the CLK input of U2, a 74C190 CMOS decade counter/divider, which provides the 4021 with the necessary active-high parallel-load signals. When a load signal is received, the 4021 jams the switch status into the shift register and serially outputs that data with every positive edge of the clock.

That data arrives at the serial input of U1 (a 74C595 CMOS 8-bit serial-in/parallel-out shift register with parallel data latches); the non-cascaded two extra bits of the 10-bit serial stream are simply clocked out. When the positive edge of the load signal is received, U1 also latches the parallel data, which consists of switch-closure information.

Not all Nintendo joysticks are created equal; differences in some joystick construction make it necessary to use an RC network (which consists of C7 and R4 in Fig. 4) that provides a delayed load signal for the joystick's internal shift register. That ensures that the parallel data of U1 is

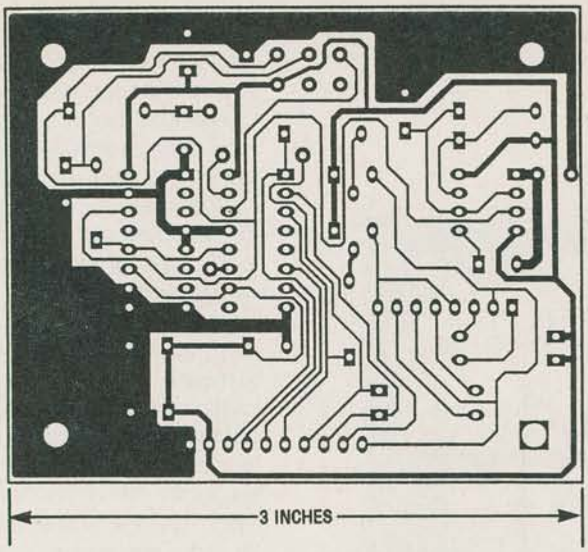

Fig. 5. Both versions of the NinJA were built on the same single-sided printed-circuit board; a template of the pattern is shown here full size.

latched at the proper position. (The values of C7 and R4 shown were determined by trying out several Nintendo joysticks and adjusting the component values until the parallel signals were latched at the expected bit position of U1 with all the various joysticks.)

In the NinJA-9, the latched active-low parallel outputs of U1 (which indicate a switch closure on the Nintendo joystick) are routed to the computer to function as the computer-joystick signals. In the NinJA-15, those output signals are manipulated by the digital-to-analog circuitry that consists of D1–D4, R5–R7, Q1, and Q2 to synthesize the analog signals that the IBM PC recognizes as directional movements of the joystick.

IBM PC Joysticks. In the case of a regular IBM analog joystick, some tweaking of its potentiometers is usually required during the initial set up to "electrically center" the joystick; each program that accepts joystick input must be told ahead of time what values it can expect for minimum and maximum X- and Y-axis stick movement. That process is circumvented by the NinJA-15's somewhat unusual digital-to-analog circuitry.

Although that circuit is not "digital-to-analog" as in the usual sense—outputting an analog signal whose magnitude varies with an n-bit wide digital input—the NinJA-15's DAC will output one of three possible analog signals to function as the X signal (right/left movement along the X axis), and one of three possible analog signals to function as the Y signal (up/down movement along the Y axis), depending on the status of the switches on the Nintendo joystick. With the joystick's handle is centered, the X- and Y-axis signals fed to the joystick port are approximately 0.1 mA.

With the handle in the southeast corner, both the X- and Y-axis the currents drop to exactly half (0.05 mA). In the northwest corner, the currents for both the X- and Y-axis signals will make a large jump (to about 2 mA). Although those values are cited as examples and vary slightly between IBM-compatible PC's and analog joysticks, the relative magnitudes always exhibit the same behavior, and it is that property that is exploited by the NinJA-15 to make it appear that there is a true analog joystick connected to the IBM-compatible computer when in reality there is none.

Without any button pressed on the Nintendo joystick, all the parallel outputs of U1 are high, forward biasing D1 and D2. That, in turn, reverse biases Q1 and Q2, in conjunction with the continually forward-biased D3 and D4, which function to set up a minimum baseline current. That emulates an "electrically centered" analog joystick.

When the RIGHT button on the Nintendo joystick is closed, D1 becomes reverse biased (U1 pin 15 goes low) and the X-axis current will be cut exactly in half since the voltage drops across D1 and D3 are identical.

When the LEFT button is closed, U1 pin 1 goes low, forward biasing Q1, sourcing around 2 mA for the X-input with a small contribution from D1 and D3 thrown in for good measure. The handling of Y axis is analogous to the X axis. The NinJA-15 owes its "auto-centering" to the fact that the voltage drops across the paired diodes D1/D3 and D2/D4 will always be the same (assuming paired diodes of identical composition).

Construction. Both versions the NinJA were built on the same single-sided printed-circuit board as shown in Fig. 5 (which is available alone, as part of a kit of parts, or as a fully assembled unit from the supplier listed in the Parts List). Its corresponding parts-placement diagram is shown in Fig. 6; note that the connector shown here for PL1 corresponds to that of the NinJA-9 version. There are also three jumpers that need to be placed on the board.

Depending on whether you build the NinJA-9 or NinJA-15 version, the DB-9/DB-15 cable connection to the NinJA will be different; Table 1 shows the proper connections to configure the NinJA printed-circuit board for the desired version. If you opt to build the NinJA-9, components D1–D4, R5–R7, Q1, and Q2 are unnecessary.

If desired, you can solder the Nintendo joystick connections directly to the NinJA printed-circuit board at PL2 (as shown in Fig. 6), but for maximum flexibility in switching between joysticks or using the same joystick with a Nintendo game, it is recommended that you purchase a Nintendo-joystick connector cable. Such cables, which are usually billed as "extension cables," are readily available at retailers dealing in Nintendo-related products.

Prepare the cable by cutting the female connector from the cable and retaining the male connector along with the cable. Remove a length of the outer insulation from the end of the cable, then strip the insulation from the inner wires and solder the wires to the NinJA printed-circuit board at the proper positions. Use an ohmmeter to verify pin-to-conductor continuity before soldering the conductors to the board. Plug PL2 is represented in the parts-placement diagram as a Nintendo joystick connector to aid in assembly.

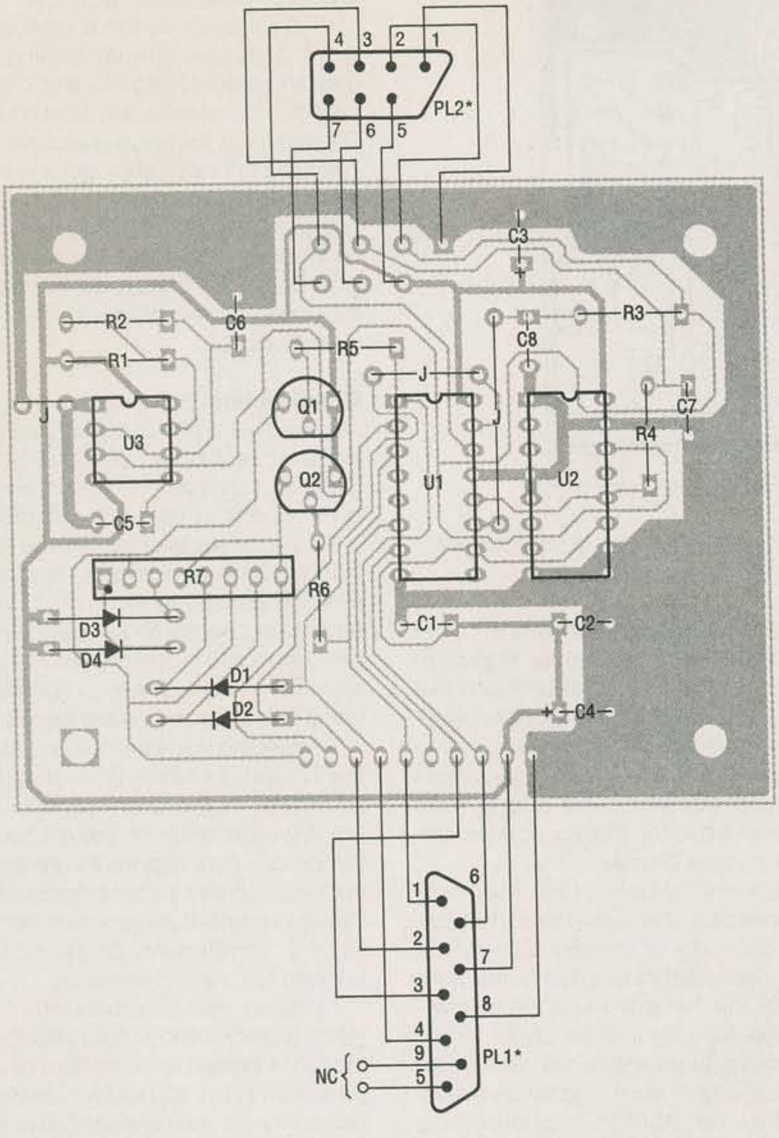

Fig. 6. Although both versions of the NinJA were assembled on the same printed-circuit board, the two versions do differ in some small way. Refer to the text to determine how the version you choose should be assembled, and refer to Table I for PLI wiring instructions that go with your version.

Care should be taken when installing U1–U3 since CMOS devices are sensitive to electrostatic discharge. Also verify that all polarized components and parts with specific pin orientations (such as the transistors, diodes, and IC's) are properly aligned before soldering them in place.

If you have trouble getting the SIP resistor network (R7), it can be replaced by 4 discrete 47k resistors. Under that circumstance, try to match their actual values as closely as possible. After all the parts have been soldered in place, perform the usual checks for misplaced components, cold solder joints, solder bridges, etc.

The printed-circuit board was designed to fit into an attractive Serpac manufactured enclosure (model 031) available from Digi-Key Corp. (701 Brooks Ave., P.O. Box 677, Thief River Falls, MN 56701-0677; Tel. 800-344-4539) and other sources. Holes in the front and rear of the enclosure were drilled for the two protruding cables, and rubber feet with adhesive backing were placed on the bottom to help prevent the NinJA from sliding around.

Set-up and Use. The NinJA-9 requires no adjustment or calibration of any sort. Just plug it into your computer and a Nintendo joystick into the NinJA-9, and you are ready to play your favorite senselessly violent game! Computers that are compatible with Atari-style joysticks support only one button per joystick; the action or "fire" button is button "A" on your Nintendo joystick. Buttons "B," "start," and "select" on the Nintendo joystick will have no function.

However, it has come to my attention that some of the newer Amiga software will recognize a second joystick button. If desired, you may connect pin 9 of the DB-9 connector to pin 5 of PL1 to get the circuit to recognize the "B" button of the Nintendo joystick as the second button for some programs.

NinJA-15, unlike a typical IBM analog joystick, requires no adjustment or hardware calibration. Since the NinJA-15 sports "auto-centering" circuitry, there are no potentiometers to tweak and no hardware-calibration programs to run. Like the NinJA-9, just plug the NinJA-15 into your computer and a Nintendo joystick into the NinJA-15, and you are ready to play! Don't be surprised, however, if when the program is executed, you are asked something like "move joystick to northwest corner and hit a button" or something similar. That's a calibration throwback for software users who own analog joysticks.

IBM computers equipped with game cards/game ports support two action buttons per joystick; your computer will recognize button "A" of your Nintendo joystick as button 1 and button "B" as button 2. The "start" and "select" buttons on the Nintendo joystick will have no function on your computer.

Troubleshooting. If you have any trouble with your NinJA, the problem could be originating either within your computer or within the NinJA. If you own a regular computer joystick, try plugging it in and seeing if the problem persists. If so, the problem lies with your computer, its joystick port, or possibly the program. If not (or you don't have a regular computer joystick), try the following:

1. Make sure the NinJA has been assembled correctly. Check for incorrectly oriented components, cold solder joints, etc.

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2. Make sure that the software you're running supports joystick inputs and you have installed the NinJA in the appropriate joystick port as dictated by the software if your computer has multiple ports.

3. If you are using the NinJA-15 with a program that expects an analog input, you will see erratic screen movement. Try a different program!

4. If you are using a NinJA-15, make sure that you have followed any software-calibration instructions given for the particular program you're running; some programs require you to move your joystick left/right/up/down/center hitting a button occasionally. That can be avoided if the program recognizes "digital" joysticks, which the NinJA-15 (with its connected Nintendo joystick) essentially is.

5. If possible verify the proper operation of your Nintendo joystick by trying it on an NES-game computer.

6. If the problem persists, try a different game card, joystick port, program, or Nintendo joystick. ■