

## SAM: AN IMPROVED INPUT DEVICE

Named in honor of the Morse code inventor, SAM allows people to communicate by sending Morse code with a single switch. Unlike most Morse code devices, SAM allows wide latitude in the timing of dots and dashes by giving the operator audible feedback beyond a simple “key down” tone. The operator hears distinctive sounds that give cues, such as when a dot or dash is recognized and when to start sending the next letter. This feature makes SAM usable by people who have trouble mastering the precise timing of conventional Morse code. The unit is portable and inexpensive (it costs about \$50 to build and runs on four AA batteries). Because of its large self-contained message display, SAM can be used on a stand-alone basis. The device can also be used as an interface to a personal computer.

### INTRODUCTION

Several years ago I attended an open house at a local United Cerebral Palsy (UCP) center where I watched a wheelchair-bound man operate his Apple II computer using a “puff” switch—a pressure-activated switch controlled by blowing through a tube. A matrix of letters and numbers was displayed on the computer screen. The rows of the matrix were scanned (highlighted in sequence) until he activated the puff switch, whereupon the columns in the selected row began cycling until he puffed again. This process was used to select a single letter, which was passed to the Apple II as though it had been typed at the keyboard.

Although this input method appeared painfully slow and tedious, it was clear that the freedom to communicate with anyone watching the computer screen, as well as the capability to operate a personal computer, had profoundly improved this man’s life. I talked to his aide, who mentioned two problems with the system: that her friend was tethered to the computer and that the expense of the system put it out of reach of many potential users.

As a result of this experience, I developed a communication device designated SAM that improved on the setup I had observed in the following ways:

1. The unit is self-contained and thus does not require a computer for operation.
2. An improved input method using Morse code is employed for much faster selection of letters.
3. The cost is low, making SAM affordable for anyone who can use it.
4. Wide variation in Morse code timing is permissible because SAM can recognize and display imprecisely timed code.

The fourth improvement turned out to be the most important in making SAM usable by the greatest number of operators. The requirement to decode imprecise Morse code was learned by hard experience. The first SAM prototype required standard Morse code, and I found that the therapists, much less the patients at UCP centers, could not

master it. As I will show after describing SAM’s design, this early frustration led to a discovery that allowed me to ignore the strict timing of the Morse code and make SAM very tolerant of imperfect code.

### TECHNICAL DETAILS

The SAM device is housed in a plastic VHS cassette box (cost: \$.75) that contains a circuit board holding four integrated circuits, including a Motorola MC146805E2P microprocessor chip and an EPROM. The SAM circuitry and software are described in United States Patent Number 4,706,067. All components use low-power complementary metal-oxide-silicon technology, and the microprocessor program is written to switch to a very low power standby mode when the unit is idle. This power management eliminates the need for a power switch and allows SAM to operate for several weeks with four alkaline AA batteries.

The unit is equipped with a standard 1/8-in. minijack, which is the usual connector for all types of ability switches, but SAM has operated successfully with a variety of switches, including finger and head switch devices.

The display is a twenty-character liquid crystal display with 3/8-in.-high characters. (A character is anything that can appear in the display—letters, numbers, punctuation, spaces.) Whenever the display fills up with twenty characters, it begins to scroll to the left. Every SAM operation (dot, dash, and letter recognition; backspace; speed setting; etc.) is accompanied by a unique sound, an audio cue, to reinforce the feedback and to permit blind users to operate the unit.

### MORSE CODE DEVICES

Morse code input devices have been known for several years, but they all suffer from a problem that is magnified for a physically disadvantaged user: the time intervals of

the Morse code are precisely defined and inflexible. Maintaining these precise intervals is difficult even for an able-bodied user and much more so for one with impaired motor ability.

### PRACTICAL DIFFICULTIES

Morse code is defined by precise time intervals of dots and dashes: a dot is a short beep; a dash is a longer beep. To be precise, the duration of a dash is defined to be exactly three times the duration of a dot. Most people have little trouble sending or recognizing dots and dashes.

A much less obvious timing requirement, and one that gives new users the most difficulty, is that the silent intervals between dots, dashes, and characters must also be precise. For example, consider the letter A, whose Morse code representation is dot-dash (Fig. 1). If the dot is sent with duration  $T$ , the dash is prescribed to be sent with duration  $3T$ . But what about the silent interval between the dot and dash? The answer is that intercharacter spaces (the silent intervals between dots and dashes of a character) are defined to be  $T$ , or one dot time, in duration. After the A has been sent, a silent interval of duration  $3T$  is required before beginning the next letter. This interval signifies that the previous combination of dots and dashes is to be interpreted as a character.

As a more complex example, Figure 2 shows the timing required to send the word ATE.

My research revealed that the silent (switch-up) intervals were much more difficult to master than the tone (switch-down) intervals. I noticed that the most difficult letter to teach is O (dash-dash-dash), which a typical untrained user would send as shown in Figure 3 as against the correct way shown in Figure 4.

Holding the switch down and up for equal time intervals as in Figure 3 actually produces three  $T$ 's instead of the desired O. I found this rhythmic subtlety difficult to teach, but I tried beating out time and saying,

*Not* down . . . up . . . down . . . up . . . down . . . up,  
*but* down . . . . . up-down . . . . . up-down.

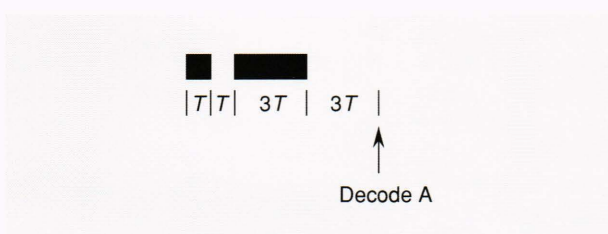


Figure 1. Timing for the letter A.

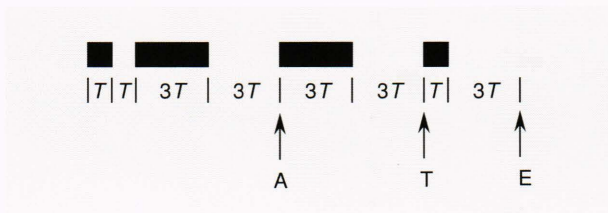


Figure 2. Timing for the word ATE.

This strict timing is difficult to convey, especially if the operator is physically disadvantaged. What was obviously needed was a means to teach an operator to send error-free code without having to learn precise rhythmic patterns.

### SAM IMPROVEMENTS

My early setback with the UCP therapist led to a breakthrough. After numerous experiments, I found that imperfect code could be recognized if the user were given audible feedback for each dot and dash he or she was attempting to send. The unit achieves this feedback by producing a tone when the switch is pressed. The tone pitch then changes when the dot time has elapsed, thus indicating the beginning of a dash. In this way the operator actually hears SAM's decision point in time as it distinguishes between a dot and a dash. This feedback provides two major benefits: it allows the detection tolerance for dots and dashes to be greatly increased, and it vastly simplifies the training to use the device. Only the following three rules must be learned, none of which involves precise timing:

1. To send a dot, activate the switch until a tone is heard; then release the switch. (Try sending an E, which is a single dot.)

2. To send a dash, activate the switch and hold it until a tone change is heard; then release the switch. (Try sending a T, which is a single dash.)

3. After sending the last dot or dash of a letter, wait after releasing the switch until the letter appears in the display before activating the switch to start sending the next letter. (Try sending an A, which is dot-dash. Hold down the switch until a tone is heard; then release the switch. Next hold the switch down until a tone change is heard; then release the switch and wait for the letter to appear.)

It is always wonderful to watch a new user go through these three steps and react with astonishment as the letters E, T, and A appear in the display.

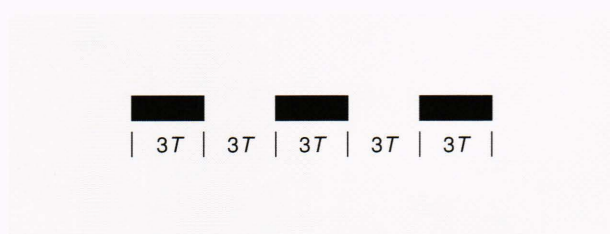


Figure 3. Incorrect timing for the letter O.

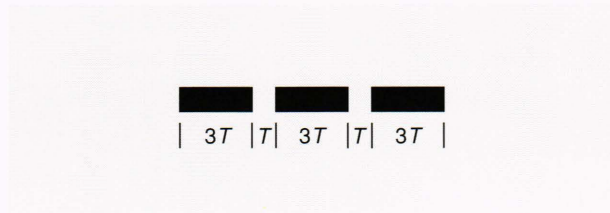


Figure 4. Correct timing for the letter O.

Armed with these rules and a Morse code chart (Fig. 5), I went back and tried SAM with all users who initially had trouble with it. A 100% success rate was realized.

### OTHER SAM FEATURES

Several additional features have been incorporated to make SAM easier to operate and master.

#### Speed Control

The device can be adjusted for various sending rates. Pressing a two-way switch on the side of the unit displays a special thermometer gauge in the readout, which temporarily overrides the normal message display. Pressing the switch up advances the gauge toward a letter *F* (fast), and pressing it down advances the gauge toward a letter *S* (slow). When the desired speed is selected, releasing the speed switch restores the normal message display after a few seconds. I have found this adjustment to be noncritical if left in about the midrange position. Its main function is to allow the user to increase the communication rate as proficiency with SAM is gained.

#### Backspace

If the operator makes a mistake, it can be erased by holding the switch down past the time required to send a dash. Thus, the operator will hear (1) the dot tone, (2) a change in pitch—the dash indicator, and finally (3) a short beep as the erroneous letter is removed from the display. A cursor under the letters moves back one space to show that the letter should be reentered.

#### Code Error

It is possible to send valid dots and dashes that represent a nonexistent Morse character. If this happens, the cursor moves quickly right-left accompanied by a two-tone tick from the speaker. These actions signify that the

dot-dash combination has been decoded, but it is an unrecognizable character and therefore is ignored.

#### Clearing the Display

Holding the switch down past the backspace interval clears the entire display and positions the cursor at the first character position.

#### Training Mode

The unit has a training mode in which the letters of the alphabet are displayed in sequence with the corresponding dot and dash patterns next to them. As each letter is displayed, the user sees and hears the letter and Morse code combinations and can press the switch in step with the sounds to get a feel for the timing. This mode is also useful for a therapist to match the receiving rate to the ability of the sender.

#### Space Character

A special character, dot-dot-dash-dash, is used to send a space. In real Morse code, the end of a word is signaled by a long silent interval. The advantage of using a special Morse character for a space is that the user can take time between letters and not worry about incorrect words being formed.

#### Computer Interface

Whenever SAM detects a space character, it can send the word that precedes the space out through a port that can be interfaced to a computer. This interface might be a serial port, which is compatible with most personal computers, or a specialized keyboard emulation port for a particular computer. Although keyboard emulator ports have not been implemented in the current model, I have tested such ports for both the IBM PC and the Apple Macintosh (using the Apple Desktop Bus). The advantage of emulating a keyboard is that no special software is required in the personal computer—it thinks words coming in via the SAM port were typed at the original keyboard.

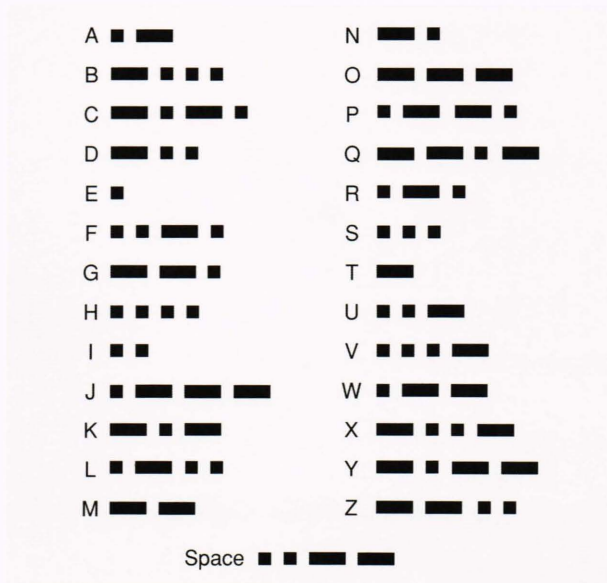


Figure 5. The Morse code chart used for SAM tests.

### EXPERIENCE

Developing and refining the SAM unit have given me an eye-opening look at the business of providing helpful devices to people with handicaps. I quickly discovered that SAM serves a niche within a niche. Its intended use is for people who cannot speak or manipulate a keyboard but who are able to operate a single switch. This characteristic obviously narrows the population of potential SAM users. Inside this limited group, moreover, wide variation exists in motivation and cognitive ability, which further limits the number of people who can use the device. One heartbreaking example is a man with cerebral palsy who was quickly able to send letters and form words with SAM only to conclude that he did not want to proceed. His therapist said that he got bored with SAM, as he did with most things.

Reaching the very specialized group of people who can benefit from SAM is difficult. Because of its restricted

audience and low-volume potential, it is not easy to interest a manufacturer. The Johns Hopkins competition provided the best conduit for information I have yet found. Although I garnered little specific information from this event about avenues to develop or distribute SAM further, the editorial coverage surrounding the competition has put several potential SAM users in touch with me. I continue to build and distribute SAM units as a hobby.

#### THE AUTHOR



LANE T. HAUCK has worked in the fields of electronics and computer design for twenty-five years. He received a B.S. in physics from UCLA and an M.S. in computer science from California State University at Los Angeles. He has worked in an acoustics laboratory for Lockheed Aircraft, as a designer of high-speed signal processing equipment for Spectral Dynamics/Scientific Atlanta, and as Director of Research and Development for Gremlin Industries/Sega, where he designed a dozen video games. Mr. Hauck currently works for Proxima Corp., a manu-

facturer of liquid crystal display systems that project computer screens for group viewing. His Cyclops invention, a remote mouse system operated from a projection screen, has won several academic and industry awards.