MagicScore bowling scorer—A microprocessor application for fun and profit

by REG A. KAENEL
AMF Incorporated
Stamford, Connecticut

ABSTRACT

Microprocessors have made the implementation of automatic bowling scorers practical. A specific scorer design will be described and illustrated, development considerations associated with this scorer will be discussed, and the future of microprocessor applications will be projected.

Automatic scoring has finally come of age. It has been around for a long time. At stake is a market represented by some 150,000 bowling lanes in the United States alone. AMF Incorporated demonstrated the first working model of a mechanical score board in 1946 when it presented the first automatic pinsetter at the ABC tournament in Buffalo NY (Figure 1). Automatic score keeping was way ahead of its time and far from being economically viable in those days.

Advances in semiconductor technology made automatic score keeping increasingly more practical ever since then. Accordingly, three different scorers were introduced two decades later with solid-state electronic control. The Automatic Scorer by Brunswick Corporation and the ScoRite scorer by Itek subsidiary, Doban Laboratories, both used a printing projector, by which scores were mechanically impact-printed on transparent pre-printed forms which were projected onto a screen through an optical system. An experimental model of the MagicScore bowling scorer system by AMF used CRT displays. Detection of standing pins was accomplished electromechanically with both the AMF and Brunswick systems using existing pin light switch-mechanisms of the automatic pinsettters. The Itek system used an array of photodetectors and directional light sources to perform this pin detection function. Each Brunswick console served two pairs of lanes, each AMF and Itek console one pair of lanes, but the AMF consoles were controlled from a central unit (Figure 2) for up to 30 consoles shown in Figure 3. Brunswick was the only company which immediately began production of their scoring system. The recent emergence of the microprocessor provided the technological advance necessary for making viable the implementation of a sophisticated automatic self-contained scorer system (Figure 4).

Additional electronic scorers have been introduced since the demonstration of those first ones. They included the semiautomatic Scortronic System by Sharp, the Automatic Scorer by Ikegami Tsushinki, the Meltas system by Mitsubishi Electric, the Automatic Bowling System by Kinetic Systems and the automatic Rapid-Score System by RCA. During this period AMF began marketing a semiautomatic scorer (i.e., EasyScore) on an interim basis to bridge the gap until the viable fully automatic MagicScore bowling Scorer system became ready for production. Pinfall data is entered by hand through keyboards with the semiautomatic systems in contrast to the automatic systems where data can be keyed in by hand if need be but which data normally is entered electrically from suitable pin-detectors. All recently introduced systems have self-
contained player consoles, except for the RCA system which uses a central processor and a central printer; all these systems use CRT display devices for clarity and simplicity of operation. The AMF and RCA systems provide for a manager console by which various administrative control functions can be performed over player consoles, such as game monitoring, establishing a practice mode of operation, and displaying the state of these consoles.

It is generally acknowledged today that bowlers prefer automatic to hand scoring primarily because it gives more time to socialize and to relax. Hand scoring is viewed by many bowlers as a disagreeable task which requires concentration and makes the scorekeeper subject to criticism for making an error. Of hand scoring's two major elements, doing the arithmetic is more objectionable than recording the pinfall, particularly among women. The reasons why arithmetic is disliked are the concentration required, the fact that some bowlers feel inadequate regarding arithmetic, and the fear of making a mistake. This last reason also applies to recording pinfall. Hand scoring is considered a nuisance and a distraction from bowling involvement. It is not that scoring is unimportant, it is simply that bowlers feel involved in the game without manually keeping score.
OUTLINE OF FUNCTIONAL SUBSYSTEMS

The basic format of the bowling score sheet, as approved by the American Bowling Congress, best depicts the progress of a game of bowling. Accordingly, it was decided that the bowling scorer display subsystem emulate its key features, (Figure 5) as well as the printer subsystem (Figure 6) with which permanent records of games are produced. A cathode-ray tube display medium was selected for its outstanding brightness and clarity. To maximize size of the pinfall-data characters (Figure 5), each bowler is designated by three letters and the frame-by-frame subtotals were omitted on the display. A novel thermal printer was found to be most cost-effective, reliable, and maintenance-free since it has only one moving part (i.e., the paper-feed stepping motor) and only requires replenishment of thermally-active blank paper (Figure 7); a total print-out, which includes running subtotals by frames (Figure 6), is produced after the game ends. Display characters are made up from dots of a $5 \times 7$ matrix with a non-interlaced horizontal raster-scan where the same pattern of dots appears on adjacent pairs of scan lines; in contrast, printed characters use $5 \times 5$ dot matrix. Extra print-head dot elements are provided for producing the grid-lines of the print-outs.
The following data must be defined at the outset to initialize a game of bowling: names of the players in bowling sequence, handicap of each bowler, and the designation of pacers whose score is not added to the team totals or blind bowlers who will not physically bowl but whose game average score is entered during initiation. The scorer derives representative pinfall data from the average score entered, and displays it when it is the blind player's turn to bowl as if this player actually bowled. In addition, the system must be placed in either the open or league mode of sequencing; in the open playing mode the bowlers assigned to a lane bowl in a round-robin fashion, but in the league mode the bowlers of a pair of lanes are sequenced to bowl alternately on both lanes. Initialization of the scorer is performed through a center keyboard shared by the players of the pair of lanes served by the particular scorer (Figure 8).

Ruggedness, flat sealed construction, and tactile feel were guiding requirements for the development of this and the other scorer keyboards.

During the initialization operation, the operator first selects the sequencing mode (i.e. Open or League) which becomes indicated on the console by LED indicators. A particular player-row is then chosen by designating left or right side, if the proper side has not already been selected, followed by selecting the proper row. This selection will be visually acknowledged by a cursor that appears over the number of the display row. Next, the field is selected in which data will be entered from the keyboard. Depressing the Player Name key produces a cursor on the bottom row below the 6th player row where the next name character entered will be displayed. Up to 16 characters are accepted and displayed on the bottom row; but only the first and the next two characters that are preceded by a space are displayed in the name field of the player row selected. In contrast, the full 16 character name appears in this name field of the print-out. All cursors are removed when a new side selection is made; no cursors are reproduced on the print-out since they are used only to cue the bowlers during data entry. Sequence mode selection becomes inhibited when the first pinfall data is entered; at that time, a player cannot be unbinded or un-pacered.

Being fully automatic, the bowling scorer begins cueing players to bowl once the system has been initialized with the data of the first players. The players who are to bowl are called by their full names which are displayed on the bottom display line on the lane-side they are to bowl on. In addition, arrows appear in the fields where the next pinfall data will be entered, pointing to the lanes from which the data will be taken.

Two extra keyboards, dedicated each to one laneside, are available to provide for out-of-order player-sequencing and error correction of pinfall-data (see Figure 9). Forcing a player in out-of-sequence is accomplished by depressing the desired row-number key on the home-side of the team the player belongs to.

The MagicScore bowling scorer can be operated as an option in the semiautomatic mode by setting a concealed switch to that mode. In this mode pinfall data is entered by way of the score-key array located on the
Figure 9—Close-up view of the Console Keyboards, showing center keyboard and dedicated additional keyboards.

Figure 10—Close-up view of the MPU electronics board (left) and Display Processor board (right).

The electronic scorer logic is contained on two printed-circuit boards which are mounted behind the keyboard subassemblies on the front panel hinged for ease of access (Figure 10). The printer drive electronics is contained on a printed-circuit board mounted on top of the printer subassembly itself to make it even more of a readily replaceable functional unit. The electronic logic is partitioned onto a microprocessor board (left side board as seen in Figure 11) and a display processor board (right side board of Figure 11). The overall logic schematic is shown in Figure 12.

The microprocessor board contains an M6800 type microprocessor with three Peripheral Interface Adapters of the M6800 family of components, one Asynchronous Communications Interface Adapter which connects to a common serial communications bus, and five 2000×8 bits read-only memories which store the scorer control software. It also includes a six-position DIP switch array by which each scorer can be assigned.
a unique address which it uses to recognize messages on the communications bus. The display processor board contains the random-access memory of the scorer in addition to the circuits that produce suitable video signals for the display monitors (Figure 13). A rechargeable standby battery is provided for these random-access memories to preserve pinfall data for many hours during power failures.

The scorer software, whose flow-chart is shown in greatly simplified form in Figure 14, provides for processing score data from the keyboard (Figure 9), the pinsensor and the manager console. The pinsensor receive routine creates a compatible pinfall data word from the incoming width modulated data (i.e., a binary zero is represented by a pulse of duration $10 \times 8$ ms, the left-lane delimiter pulse by a pulse of duration $16 \times 8$ ms, and the right-lane delimiter by a pulse of duration $22 \times 8$ ms; binary ones and zeros are serially accumulated in a shiftregister as they arrive and this word is forwarded to the pinfall-data processing routine when a delimiter is detected), executes the manager-console subrouting (i.e., read, interpret, and execute data received by the asynchronous communications interface adapter), increment timers (e.g., time-out for clear key-activation and for indicator flash control), and activate indicators. An executive program sequentially performs such functions as producing signals for the printer, calculating score subtotals, computing the next bowler to play and cueing him, etc.

During program execution the microprocessor deposits display and other data in the random-access memory of the Display Processor board and retrieves such data from this memory. Concurrently, the display processor electronics fetches data from this memory and processes it for display (Figure 13).

Each row of display characters is made up from 28 scan lines. A complete line of display characters from both display sides is transferred from the random-access memory into a recirculating shiftregister during the first two scan-lines of each character row, and recirculates there for the full duration of this row. The characters of the left screen are located at even addresses of the random access memory, those of the right screen at odd addresses; points to the left and right side display characters are similarly interspersed in that shift-register. A character column counter designates the column number of the character that is being scanned across by the cathode-ray tube beam at every instant. It is used to read the left-side data from the random access memory during the top scan line of
each character row and the right-side data during the second scan line.

As the character count is advanced, the left-side character is converted into a suitable pattern of seven dots by means of a character read-only memory. This pattern is stored in the left-side buffer shiftregister. The same process is immediately repeated for the right-side characters. These dots are then serialized and outputted to the respective display monitors.

A state read-only memory is used to define the width of each character (i.e. seven counts when part of a string of characters and ten counts when followed by a vertical line), the presence of a horizontal gridline, the presence of a horizontal synchronization signal, etc.

Means are also provided for selectively directing either the left-side video signals or the right-side signals to a video bus of the manager console. When both sides are selected, this is decoded to blank out the display monitors. This switching function is provided by the manager console which has access to all of addressable space (including RAM and peripheral interface adapters) through the microprocessor by way of the asynchronous communications interface adapter.

The component efficiency afforded by a microprocessor is evident (Figure 11). Not so is the extent by which the use of a microprocessor facilitated the developmental task: operational aspects of the control software were defined as the hardware was being developed, and operational refinements were incorporated while the system was being tested. The flexibility of a microprocessor based design made incorporation of ancillary functions both compelling and practical. The manager console feature is a case in point. It was decided to provide flags in random-access memory by which a manager can remotely control the bowling scorer consoles via a serial communications bus. The functions made available through these consoles includeblanking out scorers, monitoring lane activity through respective display, disabling the clear function at a console so as to preserve the count of games and frames bowled, and projecting messages onto an individual display screen.

Operational details are described in the User Instructions attached to the MagicScore Bowling Scorer which will be demonstrated during the presentation of the paper at the conference.