An electronic system using RF Transmitters, Receivers, Transponders and a Computer are used to measure location and distance. Using a unique method, this system measures the delay between direct and echoed RF signals from different aspects to convert RF propagation delay into triangulated distance information. It is configured to act as a measuring tool for the linesman in the game of football. It is used to spot the ball (determine location), determine if a first down has been achieved (measure/calculate change in location) and aid the linesman in centering the ball on the playfield and assess penalties (give a constant location reading).

Unlike radio direction finding methods of locating a football, it has no moving parts and is completely cordless.
The Wand

Handle houses Logic Unit, Transceiver and Batteries

Telescoping Antenna

Wand Pictorial View

Fig. 1

Approx. Scale 1 foot

DC-DC Converter and Batteries

Fig. 2
The Repeater Unit

Antenna

Antenna height 18 inches

Digital Transceiver

Logic Unit

DC-DC Converter and Battery

Repeater Schematic Block Diagram

Fig. 4

Repeater housing

Repeater housing encloses transceiver, logic unit and battery

Fig. 3

Antenna attaches with a snap to prevent damage and player injury

The antenna is covered with foam rubber so it can double as playfield corner marker

Repeater Housing is pointed for inserting into the ground
The Master Receiver, Master Logic Unit and Optional Scoreboard

**Diagram**

Master Receiver and Master Logic Unit are housed in standard computer chassis when scoreboard is not ordered.

**OPTIONAL SCOREBOARD**

Fig. 7

The Scoreboard is portable and doubles as system carrying case.

Scoreboard mounts on telescoping poles.

---

**Table**

<table>
<thead>
<tr>
<th>HOME</th>
<th>14:35</th>
<th>VISITOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>00</td>
<td>PERIOD 1</td>
</tr>
<tr>
<td></td>
<td>FIRST DOWN</td>
<td></td>
</tr>
<tr>
<td></td>
<td>YDS 3.3</td>
<td></td>
</tr>
<tr>
<td>Total Yards</td>
<td>Offense 219</td>
<td>Total Yards</td>
</tr>
<tr>
<td>&lt; &gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ball Centering Indicators - direct the linesman in re-spotting the ball.

Master Receiver and Master Logic Unit are housed inside optional scoreboard when ordered.
Electronic Football Linesman

SYSTEM VIEW

Ball Spotting:
The Master Receiver and Master Logic Unit measure the delay between the Wand transmission and that of the 4 Repeaters to determine ball position.

Ball Centering:
Once the ball is spotted, the two arrows on the scoreboard bottom aids the linesman while centering the ball.

Game Clock Control:
The Wand can also control game clock and other functions if the customer orders that option.

Repeating are located at corners of playfield.

Master Receiver, Master Logic Unit and Optional Scoreboard

Fig. 7
ELECTRONIC FOOTBALL LINESMAN

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FED.SPONSORED RESEARCH OR DEV.

[0002] Not Applicable REFERENCE TO A MICROFICHE APPENDIX

[0003] Not Applicable

BACKGROUND OF THE INVENTION

[0004] During many football games the playing field can become so torn up that determining distance and centering the ball correctly becomes impossible. When there is a question of whether the yardage for a first down has been achieved, the game must stop and the chains are brought out. An electronic system using a unique method of determining distance and location is used to eliminate these problems.

BRIEF SUMMARY OF THE INVENTION

[0005] This is an electronic system using a unique method to locate the position of the football on the playing field. It is comprised of RF transmitters, and a receiver/microcomputer that measure the RF propagation delay between direct and echoed signals to determine the football’s location. Once the location of the ball is determined “spotted”, needed information can be calculated and displayed on the scoreboard such as: distance required for a first down, total yardage, etc. In addition, the system can give position information continuously to aid the operator while moving the ball from the sideline to the center of the field (across the field), or assess a penalty (up or down the field).

BRIEF DESCRIPTION OF DRAWINGS

[0006] Drawing 1 is a System View.

[0007] Drawing 2 is The Wand.

[0008] Drawing 3 is in The Repeater Unit.

[0009] Drawing 4 is the Master Receiver, Master Logic Unit and Optional Scoreboard. All Drawings are Pictorial Views. Exact dimensions and orientations are not critical to the gist of this application.

DETAILED DESCRIPTION OF THE INVENTION

[0010] An electronic system using RF and digital components are configured such that they act as a distance measuring device. A unique method is used to measure the propagation delay of RF signals (electromagnetic waves) and derive distance. This is best understood by first describing the components of the system and then the method in which they are used.

[0011] The system is composed of four general parts: The Wand, the Repeaters, the Master Receiver and the Master Logic Unit.


[0013] The Wand is portable and acts as the system controller (see FIG. 1). The operator may control all functions of the system remotely from it. It has a Control Panel where the operator may select the operation to be made, such as, spotting the ball. An internal Logic Unit encodes all transmissions into a digital format and adds a code telling the system what type of instruction is to follow. It communicates with the rest of the system through a FM Modulated Digital Burst Transceiver. The Wand is equipped with a telescopic antenna that the operator can extend when marking the ball.

[0014] 2) The Repeaters

[0015] Each Repeater is comprised of a FM Digital Burst Transceiver and Logic Unit (see FIG. 4). When it receives a coded digital burst from the wand, it determines if it is a ball “spot” command. If so, it transmits a coded burst to the Master Receiver. The system contains four Repeaters and they are located at the corners of the playbook. The Repeater Antennas are covered with foam rubber and they double as playbook corner markers (see FIG. 3).

[0016] 3) The Master Receiver

[0017] The Master Receiver is made up of four dedicated FM receivers (only), each corresponding to a Repeater and tuned to its frequency. Also, there is a single transceiver for two-way communication with the Wand. Its function is to receive commands and echo acknowledgements. The Master Logic Unit has total control of the Master Receiver.

[0018] 4) The Master Logic Unit

[0019] The Master Logic Unit is the “brains” of the system. It is microcomputer based and is equipped with a high frequency master clock it uses as a timer. The Master Logic Unit monitors the outputs from the Master Receiver. When it receives the ball “spot” command originating from the Wand, it begins to count and record the cycles from the master clock until it receives the pulse from each of the Repeaters. It then determines location of the wand (held next to the ball) using a mathematical algorithm. The Master Logic Unit also receives command data originating from the Wand to control game clock, assess penalties, etc. The Master Receiver and Master Logic Unit are normally housed in the scoreboard, but can be housed in a standard computer chassis when the customer wishes to interface with an existing scoreboard.

DESCRIPTION OF USE

[0020] Set-Up

[0021] The Repeaters are placed on the corners of the playground. They are pressed into the ground with only the antenna showing. The antenna is covered with plastic foam and doubles as a visual corner marker. The scoreboard (optional) is mounted to portable rods that are pressed into the ground.

[0022] Calibration

[0023] The system must have a base line from which to determine distances. In other words, it must know where the “End Zones” are. The Master Logic Unit must know what the maximum and minimum signal delays are between receipt of the Wand and Repeater Signals. The system is placed in calibration mode. Then the operator goes to each
corner of the field and places the Wand next to the Repeater and presses the “spot” button activating the transmitter. The Master Logic Unit records the Master Clock count with the Wand at its closes and farthest possible points from each Repeater.

[0024] The Repeaters have an internal delay while switching from receive and transmit, that will differ between units and could present an error factor. However, this delay is eliminated by this calibration method because the mathematical algorithm subtracts the minimum delay from maximum delay leaving only the time it takes for the RF signal to propagate across the field.

[0025] Operation

[0026] The operator (linesman/official) carries the Wand during the game. Its primary function is to spot the ball. When the ball is downed, the operator marks its location by placing the Wand next to the nose of the ball and pressing the “spot” button. The Master Logic unit determines the location of the ball and updates the scoreboard.

[0027] In order to aid the operator in moving the ball from the sideline back to the center of the field, the system has a continuous “ping” mode. Once the ball is spotted, the scoreboard gives the current position of the Wand in 1-second intervals. The operator walks to the center of the field and looks at a special display the scoreboard. The Wand is moved back and forth until the special display indicates the position is the same as that when spotted. He places the nose of the ball against to the wand and play resumes.

[0028] If the operator assesses a penalty, the Master Logic Unit adds/subtracts the penalty yardage, and the system goes into ping mode directing him/her to the new line of scrimmage.

1) What I claim as my invention is a method of determining location and distance on a football field by using a differential measurement of the propagation delay of an electro-magnetic wave from a transmitter placed next to the ball. This method is described by the set-up, calibration and operation steps as follows:

a) Set-up the system by placing the repeater units at the corners of the playing field and the Master Receiver/Master Logic Unit on the sidelines.

b) Calibrate the system by placing the transmitter Wand at one corner of the playing field and transmitting an RF burst. Receiving the directly transmitted burst at the Master Receiver/Logic Unit. Measuring the difference in time until the echoed burst from each of the Repeaters arrives at the Master Receiver/Master Logic Unit. Repeating this differential measurement as the Wand is moved to the other corners of the playing field.

c) Using the measured maximum and minimum differential propagation delay, corresponding to farthest and nearest distance the Wand will be from each of the Repeaters, create a mathematical algorithm to translate this differential propagation delay into positioning on the field in yards.

d) Operating the system during the football game by placing the Wand next to the ball and sending out an RF burst, which is then used to determine the location of the football on the field.

2) Using the method of determining the position of the football on the playing field as described in claim 1, determine dynamic and statistical data about the game including but not limited to:

a) Yards to go for a first down
b) Total offense yards
c) Total yards of penalties

3) Using the method as described in claim 1, send out a continuous stream of RF bursts from the Wand to give constant position information of the Wand for the purpose of:

a) Repositioning the ball on the playing field
b) Assessing penalties

* * * * *