

## **NEW RADON MONITORING SYSTEM**

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### **OVERVIEW**

This paper describes a new radon monitoring system designed by OnGuard Systems, Inc. The OnGuard Systems Professional Radon Monitoring System is a modular system designed to make radon testing easy, accurate, reliable, and flexible. The system covers every aspect of a radon test, from the time a test request is received until the time a client report is issued. The system has three components:

1. Radon Monitor
2. Software for use on a Windows 95/98 computer
3. Null Modem Serial Cable for connecting the Radon Monitor to the computer

The Radon Monitor is controlled by user-friendly, database-driven software. There are two versions of the software. One is for primary radon testers. The other is for secondary radon testers. Either version can control an unlimited number of Radon Monitors, making it easy to increase testing capacity. The Radon Monitor is based on the world's most sensitive signal amplifier technology and includes many unique performance and reliability features. A major feature of the Radon Monitor is its 100% battery operation with a non-rechargeable battery capacity that exceeds the one-year calibration interval. The system is easily upgraded via the software.

The Radon Monitor records information about a radon test in hourly data sets, which are downloaded to the user software following the test's completion. The primary radon tester version of the software immediately calculates the hourly and average radon readings and the hourly temperature readings upon download. Results are available on-screen, including a detailed graphical depiction. A client test report is also automatically generated and can be printed immediately. Secondary radon testers obtain their results by uploading the data from their user software via a modem connection to a remote server. The data can be uploaded to the remote server at any time and without any advance notice. The remote server analyzes the data and, during the same phone connection, downloads the results to the secondary radon tester's user software where the results can immediately be viewed. The upload and download process takes less than 2 minutes. The server also automatically faxes client reports to two fax numbers of the tester's choosing.

## DETAILED DESCRIPTION

### 1. Radon Monitor

The Radon Monitor is a patented, state-of-the-art continuous radon monitor designed to provide high accuracy, reliability and simplicity of use. The Radon Monitor is fully electronic and operates on non-rechargeable, non-user replaceable alkaline and lithium batteries. The Radon Monitor is always ready to conduct a radon test because no AC power is ever needed to operate the Radon Monitor or to recharge its batteries. The batteries are sized to continuously power the Radon Monitor between annual calibration intervals. Figure 1 illustrates the Radon Monitor's mechanical layout. Its sensor is a current-type ion chamber. Radon enters a decay volume within the Radon Monitor by the passive diffusion of air through filtered, hidden, recessed openings in the Radon Monitor's sides. The filters allow only radon gas to enter the decay volume.

The alpha and beta particles from the radioactive decay of the radon and its progeny penetrate a mylar window on the upper surface of the ion chamber and ionize the air inside the ion chamber. The charges generated by that ionization and by the ionization from background gamma ray and cosmic radiation are collected and measured by a charge amplifier circuit that is one-thousand times more sensitive than any available amplifier. The output is sampled ten times per second and is analyzed in real-time. Signal processing electronics separate the output signal into alpha events and the level of radiation from the beta particles, gamma rays and cosmic radiation. Individual alpha events are validated, counted and quantified by their magnitude and collected in a histogram of the number of alpha decay events by their magnitude. Figure 2 is an electronic block diagram of the radon monitoring system.

The Radon Monitor can be likened to an electret that never has to be recharged and whose output voltage is constantly measured in real-time and analyzed in exquisitely fine detail. When the voltage on the Radon Monitor's collecting electrode (its "electret") reaches a predetermined level, the Radon Monitor reverses an applied electric field bias voltage, e.g., from positive to negative. The collecting electrode's output voltage begins to change in the direction opposite to what it was before the bias reversal because it is now collecting charges of the opposite sign. When the collecting electrode's voltage reaches a second predetermined level, the Radon Monitor again reverses the applied electric field bias voltage and the output voltage again changes in the opposite direction. In this way, the Radon Monitor operates continuously without ever having to recharge its "electret".

The alpha histogram, background radiation level, ambient temperature measurements, and other Radon Monitor performance data, including a noise signature, are accumulated in hourly records,

beginning from the time the Radon Monitor is commanded by the user software to start collecting data for a radon test. Note, this detailed information is used by the user software and is not available to the end user. Figure 3 shows a typical alpha event histogram. This is from a 71 hour test with an average radon level of around 58 picocuries per liter per hour. The alpha event histogram is generated and recorded for each of the ion chamber electric field bias directions. The hourly records are stored in non-volatile memory with capacity for 240 hours of this and other data. The Radon Monitor stops recording hourly data when commanded to do so by the user software or when 240 hours of data have been collected. This ensures that no data is ever overwritten. Once the test has been stopped, the recorded information in the Radon Monitor is downloaded to either version of the user software. The primary tester software or the secondary tester server sums the alpha histogram and calculates the hourly and average radon levels by applying Radon Monitor-specific calibration coefficients that are downloaded from the Radon Monitor with the test data. The data download speed is about 0.3 seconds per hourly record, so that a typical 48-hour radon test is downloaded in about 15 seconds. The download process is fail safe. If for some reason, a data download was unsuccessful, it can be repeated as many times as necessary.

The Radon Monitor operates continuously, even when it is not formally gathering data for a radon test. This means that self-checks of the ion chamber and its electronics can be constantly performed, providing high assurance that accurate test results can be obtained. For example, the Radon Monitor operates reliably and accurately as long as the ion chamber's output operates between the two set points, and the Radon Monitor's circuitry constantly monitors the operating range. Other self-checks ensure that every necessary communication within the Radon Monitor is taking place as expected and that sufficient battery power exists to complete a standard test. If any of these checks fail, the Radon Monitor cannot be used to start a new radon test or complete an ongoing radon test.. As additional operating experience with the Radon Monitors is gained, the alpha histogram, background radiation and noise signature data will be used for even more sophisticated operability self-checks.

The Radon Monitor displays radon levels from 0 pCi/l to 99.9 pCi/l and temperatures from 0 °F to 140 °F. The Radon Monitor is capable of measuring higher radon levels, but because of inaccuracies introduced by the multiple alpha decay events that occur simultaneously at higher levels, the higher levels of radon are not reported. The Radon Monitor's sensitivity is 0.2 alpha events per minute per picocuries of radon per liter of air. The Radon Monitor is 7 ¼ inches high, including its handle, and is 4 3/8 inches wide across the flats. It weighs less than 1.5 pounds. Its housing is made from injection molded cycoloy, a blend of ABS and polystyrene. The handle and shock absorbing bumpers are strong santoprene rubber.

## 2. Software

The OnGuard Systems Professional Radon Monitoring System has been designed to provide a totally paperless testing and reporting process. From the time a request for a radon test is

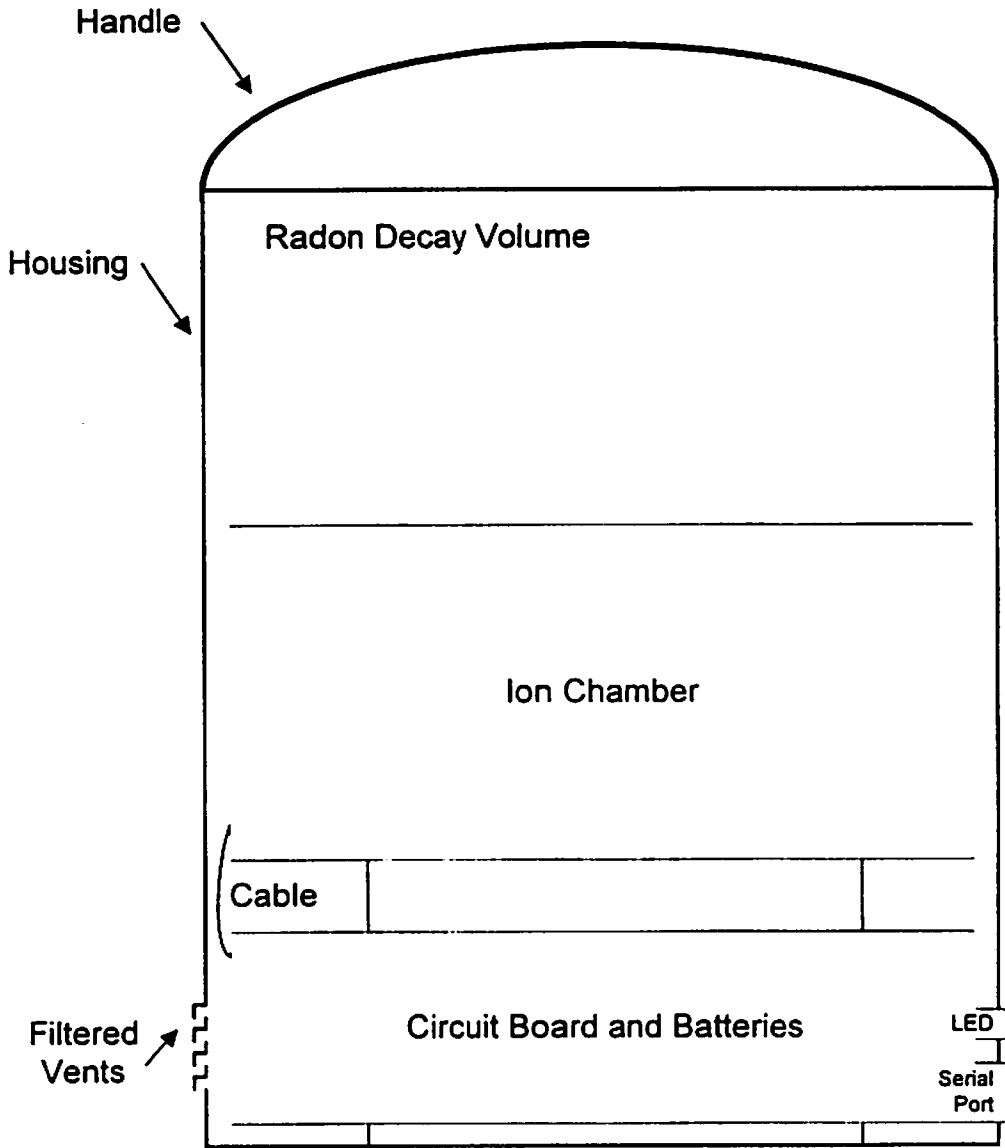
received until the time the report is printed, a piece of paper is never needed. Custom programmed software controls the Radon Monitor, keeps track of all test information and generates detailed test results and reports, including the ability to produce high quality printed reports on-site.

All information about a radon test is maintained within a unique test record in the software's database. The test records in the database are always available for editing, viewing results, printing reports, etc. The software's main features are:

- Start and stop radon tests in an attached Radon Monitor
- Repeat the data download from a stopped radon test, ensuring no loss of data from a download failure
- Control and record all aspects of the test parameters for each test individually:
  - Closed house conditions
  - Side-by-side testing
  - Vary the amount of time to delay the start of a test. This means that a radon tester does not have to return to a test site if closed house conditions were not observed when the tester went to start a test.
  - Choose to use only the last 48 hour test period in calculating the average radon level. This can be helpful if a weather front, which could impact the accuracy of a test in progress, were to pass through an area after the test had started. The radon monitor could be left to gather data for 48 hours after the front had passed. At the conclusion of the test, the tester can tell the software to use only the last 48 hour test period unaffected by the front in calculating the result.
  - All test information needed for state regulatory reporting
- Record all relevant test site and client information at anytime - before starting a test, after starting a test, or after stopping a test, including miscellaneous notes about the test, test site or client needs
- Automatically select the test record from the database which matches an attached Radon Monitor at the time a test is to be stopped
- View on-screen graphs of simultaneously plotted hourly radon and temperature data for any completed test
- Preview test reports on screen
- Print test reports on-site
- Fax the test report directly from the software in conjunction with compatible fax programs
- Customize three form letters, based on radon level, that are automatically included in the client report
- Maintain a database of all personal and/or company information for automatic use on the client report
- Export data in PC standard format for use in other programs to generate monthly state reports and to keep archives
- Delete unneeded test records
- On-screen displays of a Radon Monitor's status:

- **Calibration** – the number of days since the Radon Monitor was last calibrated
- **Side-by-side tests** – the number of tests until the next side-by-side test should be done
- **Battery level**

Figure 1  
OnGuard Systems Professional Radon Monitoring System  
Radon Monitor Mechanical Drawing



**Figure 2**  
**OnGuard Systems Professional Radon Monitoring System**  
**Electronics Block Diagram**

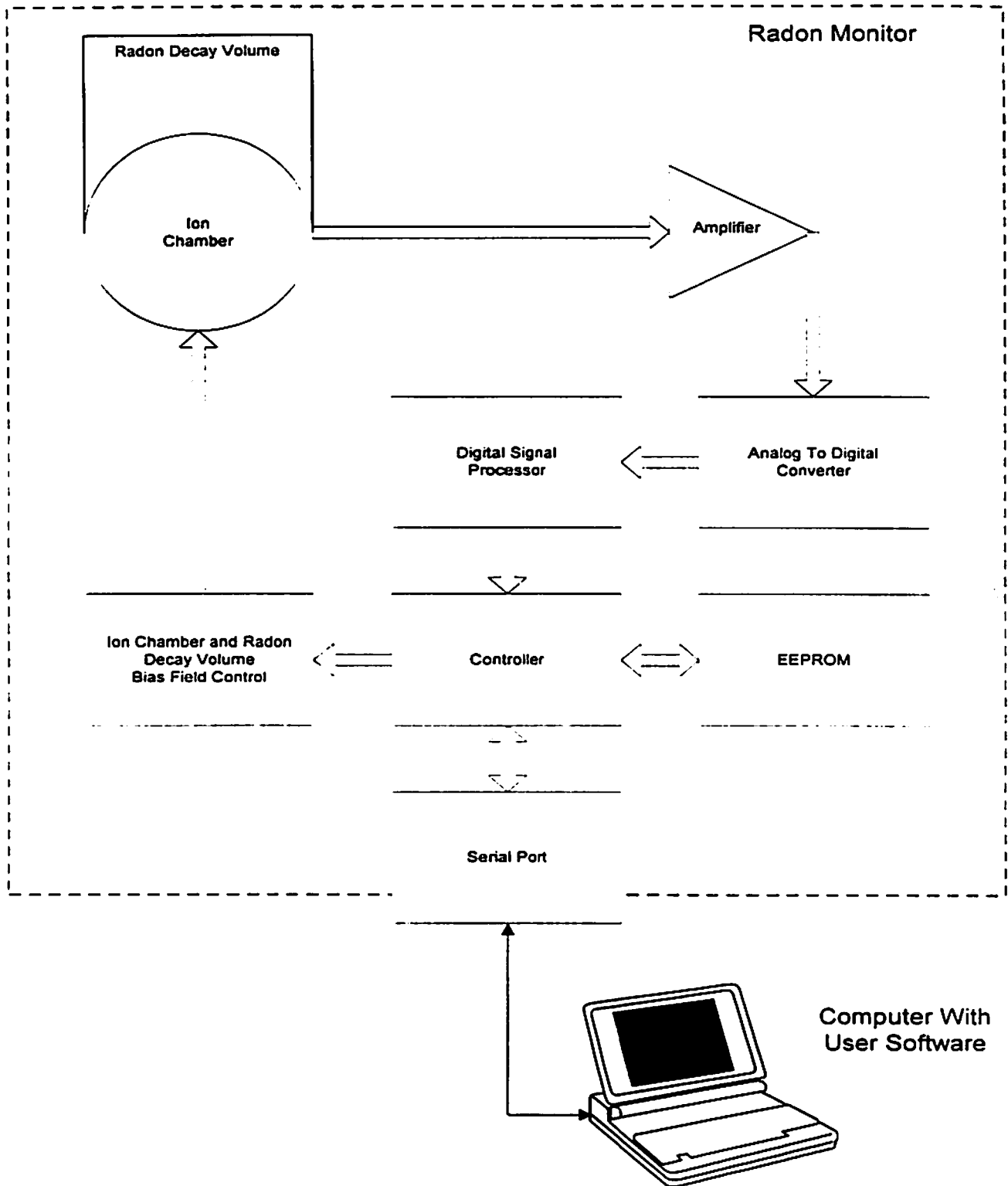


Figure 3  
 OnGuard Radon Monitoring System  
 Alpha Event Histogram

