



Safety & Security Instruments
A Division of Science Applications
International Corporation

OPERATION & MAINTENANCE MANUAL

RADSTAR SYSTEM MODELS PD-4, PDE-4 AND PDX-4



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USER'S FCC NOTICE

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of FCC Rules. These limits are designed protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Shielded cables and I/O cords must be used for this equipment to comply with the relevant FCC regulations.

Changes or modifications not expressly approved in writing by Science Applications International Corporation may void the user's authority to operate this equipment.

RadStar™

Radio Transmission Dosimetry System

PREFACE

Congratulations! You have made an excellent purchase decision. Science Applications International Corporation's (SAIC's) RadStar™ system will provide improved remote radiation monitoring performance which enables:

- New levels of ALARA conformance
- Minimum staffing and training requirements
- Rapidly deployable monitoring
- Cost effective spot monitoring
- Outage time reduction
- Improved safety

In addition, SAIC is committed to providing the total support net required for such a system which can be accessed by calling (800)-962-1632. Enough flexibility has been designed into the RadStar™ Radio Dosimetry system to handle a wide range of remote monitoring applications. Although simple networks can be powered up and run without modifying the factory default configuration, setting up the more complex network architectures will usually require some reconfiguration of operating parameters within the PD-4s™ and PDE-4s™ [or simply, PD(E)-4] teledosimeters. For this purpose, SAIC recommends the use of the included **PDRC4** application program which allows users to edit control settings within the PD(E)-4 via a PDR-1™ or PDR-1/S™ Reader. After the network has been configured, it can be monitored and controlled by the RadStar™ application program, **RS** which is also included. Both RS and PDRC4 are compatible with and can be interfaced to user written applications. Both of these application programs are referenced in this manual to provide a context for describing configuration and control operations. A limited amount of descriptive material concerning the use of these programs is contained herein; however, both are provided with on-line Help which will provide additional details concerning active keys, editing procedures, and setup procedures.

1.0 INTRODUCTION

The **RadStar™** System is the most advanced radio transmission dosimetry system available, providing detection, radio transmission, and remote display of radiation exposure information. **RadStar™** is unique in its use of BIDIRECTIONAL transmissions for high communication reliability at low RF power levels, minimizing the potential for electromagnetic interference. The primary application for **RadStar™** is remote monitoring of personnel working under severe radiation conditions where accurate radiation dosimetry is difficult. Typical monitoring problems solved by **RadStar™** include situations involving

- high radiation field gradients,
- radiation fields that are difficult to characterize with a high level of confidence, and
- potentially high radiation fields that vary with time.

A secondary application for **RadStar™** Dosimeters is as local area monitors. Each **RadStar™** Dosimeter is equipped with an external power jack, thus allowing it to monitor specific points of interest, unattended, for the duration of an outage. Alternatively, **RadStars™** can be temporarily placed to monitor the progress of processes such as chemical decontamination.

From its inception, the **RadStar™** concept has been entirely consistent with the spirit of ALARA. **RadStar™** allows the Health Physicist and his staff to monitor the progress of sensitive tasks from outside the control area. **RadStar™** products, like the PDE-4™ with 5 parallel radiation measurement channels, allow the HP to simultaneously monitor trunk and extremity doses as the radiation worker performs his task. Thus, unplanned doses due to field gradients, hot spots, and time variant conditions can be detected and remediated immediately. **RadStar™** can reduce personnel doses in yet other ways. Accurate, real time monitoring allows contingencies to be reduced, and in cases where the worker still has allowable dose after completion of a task, he can move on to another job without leaving the control zone, thus avoiding a second "entry dose".

The use of BIDIRECTIONAL transceivers in **RadStar™** Dosimeters adds a totally new dimension to radio transmission dosimetry. Now, alarm levels and transmission intervals can be changed "on the fly" as the worker moves from job to job. No longer is the radio energy simply launched into space with the hope that it will be received. **RadStar™** communications use a sophisticated error checking protocol which includes automatic retransmission and acknowledgment; if a **RadStar™** message packet fails to reach its destination, the sender is notified immediately. Bidirectionality also allows for implementation of the repeater function. Any **RadStar™** Dosimeter can be configured to repeat messages that it receives. Strategic placement of a single repeater can double the range of a communication link or bend messages around an otherwise blind corner. In the unlikely event that a network link is broken (e.g., a **RadStar™** Dosimeter moves out of range of its primary receiver), the Dosimeter automatically attempts to reroute its transmissions through a different network path.

2.0 RadStar PRODUCT FAMILY

Key components of the **RadStar™** System include the following products:

PD-4™ The PD-4™ is a mobile Transceiving Dosimeter which uses the same radiation detection circuitry that was developed for the PD-1™ electronic dosimeter. Over the years, the PD-1™ has proven itself in nuclear power plants to be the most rugged, reliable and accurate electronic dosimeter available. To produce the PD-4™, the PD-1™ circuitry was repackaged in a larger case to provide space for the spread-spectrum radio transceiver. Like the PD-1™, the PD-4™ is an independent dose and dose rate measurement system and does not require communication with a base station to acquire and store radiological data. Thus, if communications are temporarily interrupted, the PD-4™ continues its monitoring functions and then provides up-to-date total dose and dose rate data when the link is re-established.

PDE-4™ PDE-4™ is also mobile and provides the same functionality as the PD-4™ with the additional capability to simultaneously monitor up to four extremity sensors. For instance, a single PDE-4™ can provide radiological data for the trunk, both hands and both feet, all at the same time.

PDX-4™ The PDX-4™ RadBase is the base station end of the communication link. It contains the same radio modem that is used in the PD(E)-4. The PDX-4™ receives messages from PD(E)-4s and transfers them to the host PC over an RS-232 serial cable. Similarly, the PDX-4™ accepts commands from the host PC (e.g., change alarm value commands) and transmits them to the designated PD(E)-4. Spread-spectrum radios, operating in or near the GHz range, are extremely robust and provide reliable communications under a surprising variety of adverse conditions. It is not unusual to establish communications up and down elevator shafts, through reinforced concrete walls, and into Faraday cage type screen rooms. However,

SAIC highly recommends that the viability of a particular network configuration and geometry be demonstrated by test before being put into service.

PDR-1™ The PDR-1™ Dosimeter Reader provides access to the PD(E)-4's EEPROM storage area where calibration factors, alarm levels, and other system constants are stored. The PDR-1™ communicates with the PD(E)-4 through the same capacitance interface as the PD-1™ and to the host PC through a standard RS-232 serial cable. Since only alarm levels and transmission intervals can be changed via radio commands, the PDR-1™ is required for adjusting calibration factors during

calibration procedures and for configuring communication parameters and the external sensors of a PDE-4™.

Host PC Customers generally use their own PCs. SAIC recommends the use of an IBM-compatible 286 or higher end machine.

3.0 QUICK START

3.1 Hardware Connection

While the **RadStar™** System offers a high degree of flexibility, it is easy to use in simple network configurations. Let's consider the simplest possible configuration consisting of one **RadStar™** PD(E)-4 Dosimeter and one **RadStar™** PDX-4™ RadBase (Fig. 3-1). As shown in the figure, the PDX-4™ RadBase is connected to the host PC with a 9-pin to 25-pin RS-232 serial cable (included with the PDX-4™). Don't use other cables for this purpose because it is unlikely that their pinouts will be correct. The 25-pin end must be connected to either the COM1 or COM2 serial communication port of the PC. If gender-changers or other adaptors are required to make this connection, they should be of the "straight-through" variety (i.e., don't use null modem components which swap the transmit and receive lines). Next, supply power to the PDX-4™ by connecting the provided 9 V power adapter to a 120 VAC receptacle. Note that the PDX-4™ power adapter is very similar in appearance to the adapters supplied with PD(E)-4s which have opposite output polarity.

CAUTION:

Before applying power to the PDX-4™, be sure you are using a 9 V device which applies positive polarity to the center conductor of the connector.

Polarity can be verified by checking the manufacturer's label on the power adapter's case.

IMPORTANT:

The white recessed button on the front of the PDX-4™'s case (just to the right of the RS232 connector) is used to generate a non-maskable interrupt request, not a reset. It should be pressed to put the PDX-4™ into serial communication mode for configuration. A momentary interruption of power is the easiest way to reset the PDX-4™.

The PD(E)-4 Remote may be powered either by a 9 V alkaline battery or by its external power adapter. The unit's power switch should be in the "Off" position prior to making the power source connection.

CAUTION:

Before applying external power to a PD(E)-4, be sure you are using a 9 V device which applies negative polarity to the center conductor of the connector and that the power switch is in the "Off" position.

IMPORTANT:

If the power switch is in the "On" position when a power source is connected, it is probable that contact bounce will cause PD(E)-4 built-in test circuitry to disengage the main voltage regulator from the power source (there will be no powerup chirp and the display will remain blank). If this happens, turn the unit off for a few seconds using the power switch and then try again.

If the power adapter option is chosen for the PD(E)-4, it makes no difference whether or not a battery is present. If the battery option is chosen, be sure the battery is fresh. See section 4.7 for installing a fresh battery. Finally, insure that antennas are installed on both the PDX-4™ and the PD(E)-4. This completes the hardware setup for the trial network.

3.2 Software Installation

Now is a good time to install the required software on your PC. The software includes two (2) applications packages: 1) RS - the RadStar Communications Control Package, and 2) PDR4 - which allows for editing of the PD(E)-4 database. First create a separate directory to receive the software. You might name the directory PD4 or RADSTAR. The following DOS commands will do the job:

```
C:\>md radstar
C:\>cd radstar
C:\RADSTAR>_
```

Now use the DOS COPY command to copy the required files from the SAIC distribution diskettes. The necessary files are listed below:

HELP_RAD.1	HELP_RAD.2	HELP_RAD.3	HELP_RAD.4
HELP_RAD.5	RS.EXE	SETUP.VAL	
HLPDRC_4.1	HLPDRC_4.2	HLPDRC_4.3	HLPDRC_4.4
HLPDRC_4.5	HLPDRC_4.6	HLPDRC_4.7	PDR4.EXE

Start the **RadStar™** application by typing RS at the DOS prompt, e.g.,

```
C:\RADSTAR>RS_
```

Pressing the Enter key should produce the **RadStar™** title screen which will persist for five seconds (unless some key is pressed) followed by a display similar to the following:

PDX-4/PD-4 Communication Interface

Release date: 05-JAN-1994

Checking COM Port #1... PC Time-Out Error!

Checking COM Port #2... PDX-4 found

Base-Station serial driver installed at COM2

PDX-4 Serial No: 32486 ROM Version: V2.4

Radio Channel: 4 Sub-Channel: 1

RF Signal Strength (Channel,%Max):

(1,37) (2,37) (3,36) (4,34) (5,33) (6,33) (7,39)

--ESC or RETURN for Main Menu--

In this case, a PDX-4™ RadBase was located at COM2 and the selected radio channel and subchannel were 4 and 1, respectively (the factory defaults). The RF signal strength report gives you an idea of the relative amounts of ambient RF energy that is currently present in each of the PDX-4™'s seven radio channels. Smaller numbers are better; if the relative signal strength in the selected radio channel is substantially higher than the other channels, you might want to consider using a different radio channel to set up your network (described later in this manual). If the PDX-4™'s radio channel is changed, a corresponding change must be made to the PD(E)-4 as described below in "In Case of Trouble". If you obtain a "PC Time-Out Error!" for both COM ports, the application was unable to obtain a PDX-4™ response from either COM port. In this event, check cabling between the PDX-4™ and the PC and insure that the PDX-4™ is powered (the red PWR Light Emitting Diode should be illuminated). Then, reboot your PC to eliminate any serial port drivers (e.g., mouse drivers) that might have been previously installed. If the application still fails to locate the PDX-4™, refer to Appendix C (Configuring the PDX-4™ RadBase).

Once the application has located a PDX-4™ connected to one of the COM ports, press Enter (Return,Ret) to obtain the Main Menu. The options available from the Main Menu are:

- A. PDX-4 Base Station Controller
- B. Base Station Monitor
- C. B-S Monitor (HEX-to-disk)
- D. Display Help Files
- E. Base Station Controller Setup
- F. Exit to DOS

Select Option 'A' (PDX-4™ Base Station Controller) by pressing the 'A'-key. You will be looking at the **RadStar™** message screen with no entries. Now, turn on the PD(E)-4. Within 3 to 4 seconds, it should issue an audible chirp and its first message should be received and written to the screen in ROW #0. The message entry in the "Xmit Int (s)" column tells you how many seconds you must wait for the next message update. Other similarly configured PD(E)-4's may be turned on at this time and their messages will be added to the display as they are attached by

the Base Station. Note that five display lines are required by a PDE-4™; one line for the internal detector and four lines for the external probes.

3.3 In Case of Trouble

If you're reading this section, events have probably not transpired as described above. Almost invariably, communication problems can be traced to dead batteries or incompatibilities between Base Station and PD(E)-4 configurations. Check the PD(E)-4's display; if it is completely blank turn the unit off for about 10 seconds and then turn it back on. If the display remains blank or if the battery icon is visible, replace the battery (or check external power connections, whichever is appropriate). If the display appears normal (i.e., a dose or dose rate value is being displayed), press the red "CALL" button; the PD(E)-4 should respond immediately by illuminating its "RD" LED for about one second followed by a simultaneous flash of its "AT" LED and an audible chirp. If the letters, "rPr", are visible on the display, the unit has been configured as a Repeater and needs to be reconfigured as a Remote.

3.4 Base Station QUICK START Configuration

Press the ESC key to return to the Main Menu and select Option 'E' (Base Station Controller Setup) by pressing the 'E'-key. A new RF Signal Strength report will be generated and you will then be offered the option to select a new radio channel; press Enter to leave the channel number unchanged. Press Enter again to leave the radio sub-channel unchanged. Press Enter once again to leave the communication group number unchanged. You will now be looking at the following prompt (except, perhaps, for the numerical value):

```
MAX Units for this Base-Station = 10; New MAX-Units? _
```

For the purpose of discussing the MAX-Units value, it is convenient to define two terms for use in the context of this manual. The first term is "acquire". PD(E)-4s "acquire" a Base Station in the same sense that a guided missile or torpedo acquires a target. Once a PD(E)-4 acquires a Base Station, it will remain locked onto it for as long as the communication link remains unbroken. However, Base Stations are the masters of the acquisition sequence; that is, they must allow themselves to be acquired. When they do, we say that the Base Station has "attached" the Remote. Using these definitions, MAX-Units is the maximum number of attachments that the Base Station will allow. Enter a value of 10 for MAX-Units (or simply press Enter if the current value is already 10).

The next prompt is

```
MAX Direct Remotes for this Base-Station = 3; New MAX-Remotes? _
```

Attachments are termed "direct" when the Base Station attaches directly to a PD(E)-4 Remote. They are "indirect" when the Base Station communicates with the Remote through one or more Repeaters. MAX-Remotes is the maximum number of direct attachments to Remotes that the

Base Station will allow. Set MAX-Remotes = 10 or press Enter if it already has a value of 10 (note that in QUICK START, we are trying to achieve one Direct Remote attachment).

The next prompt is

MAX Direct Repeaters for this Base-Station = 2; New MAX-Repeaters? _
--

Just as with Remotes, Repeaters can be attached by Base Stations either directly or indirectly. A Repeater that communicates with a Base Station through one or more additional Repeaters is considered to be indirectly attached by the Base Station. MAX-Repeaters is the number of direct Repeater attachments that the Base Station will allow. Set it to zero for now since we are not currently dealing with any Repeaters. Lastly, you are offered the option of having all data logged into files that will be created in the current working directory. For now, refuse the option by entering 'N'. (See Appendix H for examples of PD-4™ and PD(E)-4 LOG files).

Before returning to the Main Menu, make a note of the radio channel, radio subchannel, and communication group number because the next step will be to verify that the PD(E)-4 is configured with the same values.

NOTE:

In order for a PD(E)-4 Remote to communicate with a PDX-4™ RadBase Base Station, both units must have the same radio channel, the same subchannel, and the same Communication (Control) Group number (Section 3.5 describes how these values are edited).

Press Enter to return to the Main Menu and select Option 'F' to return to DOS.

3.5 PD(E)-4 QUICK START Configuration

The principal purpose of the PDR4 application is to provide the capability for editing PD(E)-4 EEPROM values. Connect a PDR-1™ to your other COM port and run PDR4. Press any key to get past the title screen. If the PD(E)-4 unit was originally configured as a Repeater, turn it off, wait 4 or 5 seconds, and turn it back on. Place the PD(E)-4 upside down on the PDR-1™ Reader with its antenna pointed in the direction of the PDR-1s™ "DOSE RESET" button and select Option 'A' (Edit). The resulting screen displays a good portion of the PD(E)-4s EEPROM. These items will be discussed in detail in subsequent portions of this manual; however, our present concern is only that the following items have the following values:

- | | |
|-----------------------|---|
| 1) Repeater Mode | <u>DISABLED</u> |
| 2) Transmission Mode | <u>PNTtoPNT</u> |
| 3) Control Group | (same as Comm Group Number of Base Station) |
| 4) Broadcast Address: | <u>FFFFFFFF</u> |
| 5) Radio Channel: | (same as Radio Channel of Base Station) |
| 6) Radio Sub-Channel: | (same as Radio Sub-Channel of Base Station) |
| 7) Transmit Int (s): | <u>10</u> |

Use the TAB and arrow keys to position the cursor as necessary while making changes. Then press ESC to advance to the second screen and edit the following values as necessary:

- | | |
|-------------------------|----------------|
| 8) Lost-Coms to Re-Acq: | <u>3</u> |
| 9) Max Attachments: | <u>10</u> |
| 10) Max Direct Remotes: | <u>10</u> |
| 11) Max Direct Repetrs: | <u>0</u> |
| 12) Auto-'A' Command | <u>ENABLED</u> |
| 13) Attach Lower FSNs | <u>ENABLED</u> |

Now press ESC once to end the editing session and then press Enter to install the edited values in the PD(E)-4's EEPROM.

IMPORTANT:

If any trouble is encountered with data transfers between the PD(E)-4 and the PDR-1™, press down gently (a few ounces) on the back of the PD(E)-4 case to insure proper contact with the Reader. This is particularly important in the case of a PDE-4™ with attached external probes which can unbalance the unit and cause it to tilt on the Reader.

Turn the PD(E)-4 off and restart the RS application. Select Option 'A' from the Main Menu and turn the PD(E)-4 back on. If the proper response is not obtained within a few seconds, contact the factory at (800) -962-1632)

4.0 PD(E)-4 Functional Description

4.1 Radiation Detection

4.1.1 Sensors

The PD-4™ uses the same radiation detector as the PD-1™ and PD-3™, an energy compensated Geiger Mueller Tube (GMT). The GMT provides very large signals compared to solid state devices which eliminates the need for high gain preamplifiers and pulse shaping amplifiers, while providing superior immunity to microphonics and electromagnetic interference. GMTs typically over-respond at photon energies in the range which begins with their detection threshold (30 to 60 keV) and extends up to about 200 keV; hence the need for energy compensation which provides selective photon removal in this energy range. The PDE-4™ is identical to the PD-4™ with respect to the internal GMT; that is, it uses the same energy compensated GMT for its internal radiation detector. In addition, the PDE-4™ supports up to four external GMT Extremity Probes which, as their name implies, can be affixed to various portions of the body (arms, legs, head) to simultaneously monitor local doses and dose rates. The effective center of detection for the internal GMT is indicated by registration marks (+) on the top and back of the PD(E)-4 case.

To minimize size, the Extremity Probe (SAIC Assembly No. 201406) is based on an uncompensated GMT (compensation typically doubles the diameter of a small GMT). Therefore,

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Extremity Probes will overrespond somewhat in the 50 to 200 keV photon energy range. However, after calibration using a standard calibration source such as ^{137}Cs (661 keV) or ^{60}Co (1173 and 1332 keV), the data provided by an Extremity Probe will be conservative from the personnel safety standpoint. It will either indicate accurately or it will indicate slightly high depending on the relative fraction of total dose that lies below 200 keV. The relative energy response curves for the compensated internal GMT and the uncompensated external GMTs shown in Fig. 4-1 demonstrate that either GMT provides reasonable low energy response (below 200 keV).

CAUTION:

The 4-pin Extremity Probe connectors are of the push/pull variety. Do not twist these connectors while connecting or disconnecting from the PDE-4™. Align either the red dots or the black dots (whichever are most visible) to engage. SAIC recommends that the PDE-4 be momentarily powered down while external probes are being connected or disconnected to eliminate the possibilities of false counts being accumulated and component damage from the high voltage inrush current.

PDE-4™ Extremity Probes are selected from production lots based on their small sensitivity variation from the mean sensitivity. After installing the appropriate average calibration factors into the PDE-4™, the External Probes may be connected in any order to the PDE-4™ external connectors with minimum impact on measured responses. SAIC currently uses two different types of miniature GMTs during production of External Probes. These two GMTs have slightly different average gamma sensitivities (15 to 20%) and should not be interchanged with each other. The more sensitive of the two probes can easily be identified by a one inch long red cable sheath at the GMT end of the assembly. Of course, when traceability from data to sensors is mandatory, or for monitoring applications that require maximum accuracy, the sensors cannot be switched. In these cases, separate calibration factors and serial numbers for each probe should be installed in the PDE-4™. However, the SAIC probe selection process will still minimize the uncertainty in cases where probes are inadvertently switched or probe serial numbers are misread.

4.1.2 Rate Linearity

GMTs have a linear rate response over the range of rates typically experienced by radiation workers. Each GMT pulse increases the accumulated dose by the same increment (i.e., by the linear calibration factor, $\approx 1.5 \mu\text{R}/\text{count}$) and no correction is necessary up to a few R/h. At rates higher than a few R/h, the fraction of time required by the GMT to recover from previous Geiger avalanches (the recovery or dead time) becomes significant so dose and dose rate values are multiplied by the factor, $1/(1-C\tau)$ where C is the measured count rate and τ is the dead time per Geiger avalanche. The purpose of the dead time calibration procedure is to establish the proper value for τ which typically lies in the range from 12 to 25 $\mu\text{s}/\text{count}$ for miniature GMTs. With dead time correction the GMT is accurate at any rate up to 500 R/h. Above 500 R/h the unit will read conservatively high. GMT foldover will not occur at less than 10,000 R/h.

The maximum permissible cable length for PDE-4™ External Probes is also a function of the GMT dead time. For simplicity and reliability, the Geiger pulse is transmitted back to the PDE-

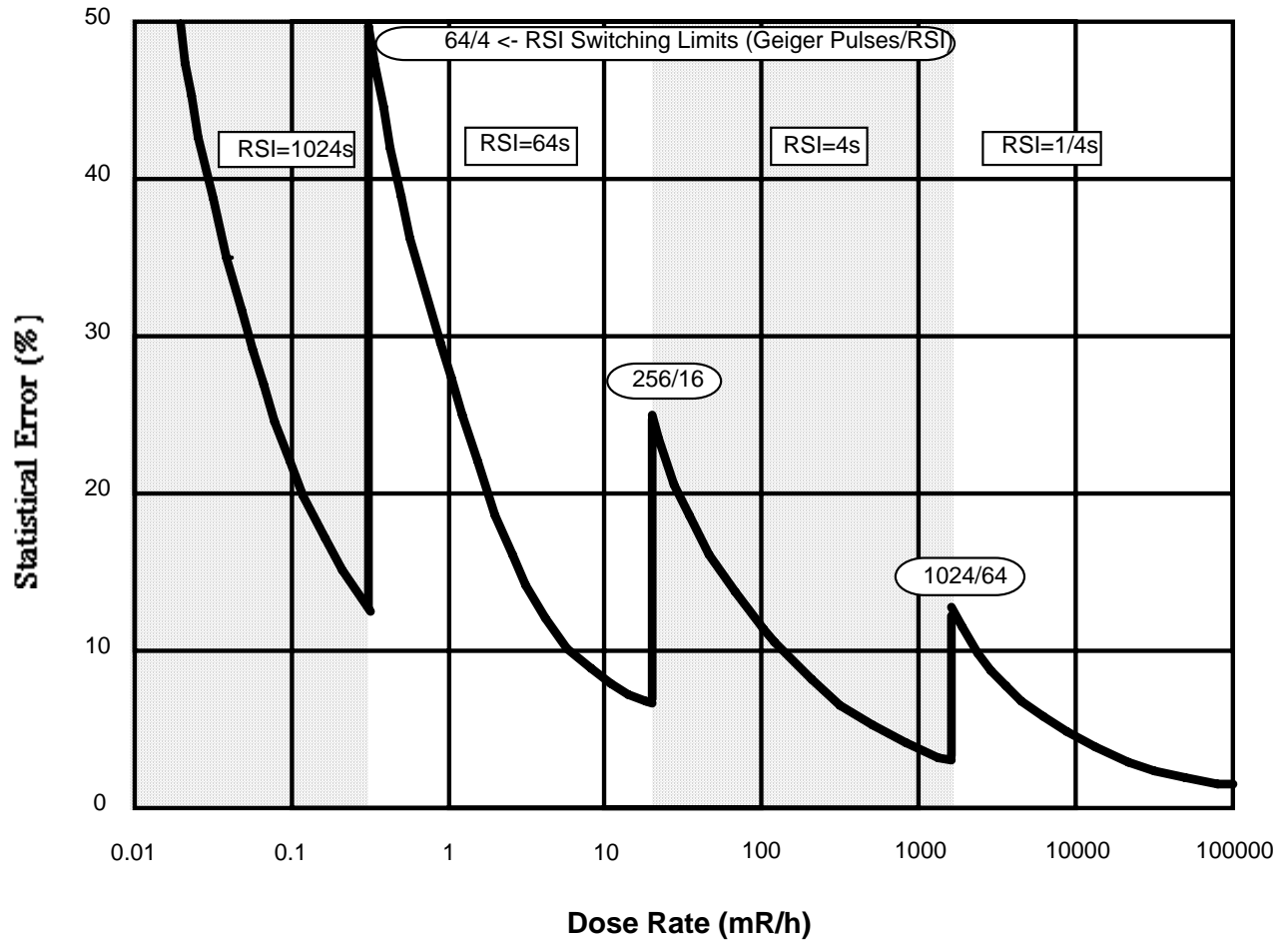
4TM by an open collector driver which leads to the inequality, $l \leq \tau/(RC')$, where l is the cable length, R is the value of the pullup resistor, and C' is the distributed capacitance of the cable. With $R=10 \text{ k}\Omega$ and $C' \approx 100 \text{ pF/foot}$, the relation becomes $l \leq \tau$ feet, where τ is in μs . Thus, for a GMT with $\tau \approx 15 \mu\text{s}$, the cable length should be less than 15 feet. Probe assemblies with cables exceeding this length will be subject to foldover at high rates.

4.1.3 Dose Rate Sampling Algorithm

PD(E)-4s are not designed as survey instruments. Nonetheless, they can measure dose rate from background to 500 R/h. The dose rate algorithm runs once each Display Period (one DSP=0.75 s), regardless of the display mode, so rate alarms can be activated even when the PD(E)-4 is not displaying a dose rate.

To estimate dose rates, the PD(E)-4 always attempts to acquire statistically significant data. At lower dose rates, longer Rate Sampling Intervals (RSIs) are used to acquire an accurate rate sample. At very low dose rates (e.g., background rates in the 10 to 20 $\mu\text{R/h}$ range), the units sample for 1024 s (≈ 17 minutes) to obtain a rate sample with reasonable statistical accuracy. As the ambient dose rate increases, the PD(E)-4 automatically decreases the length of the RSI to provide faster rate response.

Rate Sampling Intervals (RSI) for PD(E)-4



- Switching Limits. First number is number of counts to cause switch from longer to next shorter sampling interval. Second number is number of counts to cause switch from shorter to next longer sampling interval.

- Rate Sampling Interval, Time in seconds.

Rate Sampling Intervals and Switching Limits

4.2 Operating Modes

The three basic operational modes of the PD(E)-4 are DOSE, RATE and CONFIRMATION. The operating mode is changed by pressing the "Mode" pushbutton (the black button nearest the front of the case, see Fig. 4-3). The PD(E)-4 acknowledges by momentarily blanking its display and issuing a short chirp from its audio annunciator. An additional operating mode communicates with a PDR-1™ or PDR-1/S™ reader through a serial link to download data and to upload commands and setpoints. This mode is not reachable via the MODE button and can be activated only by a reader in which case "I-O" will appear on the display. On powerup, the PD(E)-4 defaults to DOSE display of Internal GMT #1; successive closures of the MODE button will cause the PD(E)-4 to sequence through the following display modes:

```
Powerup Default Internal #1 DOSE
Internal #1 RATE
External #1 DOSE (if present)
External #1 RATE " "
External #2 DOSE " "
External #2 RATE " "
External #3 DOSE " "
External #3 RATE " "
External #4 DOSE " "
External #4 RATE " "
CONFIRMATION Mode
back to Internal #1 DOSE
```

Display modes for non-functional or missing sensors are skipped.

4.2.1 DOSE Mode

In DOSE mode, the display shows the accumulated dose (in mR or R) since the last reset operation using a three-digit floating point format with autoranging. The dose is recalculated at each DSP (0.75 s) for alarm purposes even when the PD(E)-4 is in some other display mode.

4.2.2 RATE Mode

In RATE mode, the display shows the dose rate value estimated from the most recent RSI in mR/h or R/h using the same floating point format that is used for dose values. The RSI is always reset to the shortest interval (1/4 s) on entering RATE mode; therefore, the PD(E)-4 can always be forced to post a new RATE value by cycling through the display modes until RATE display of the desired sensor is reached. The new rate value will be displayed during the DSP following entry to RATE mode.

Upon entering RATE mode, the PD(E)-4 will display the current dose rate while calculating a new dose rate based on the 1/4 s RSI. After approximately one second, the new rate value will be written to the display. If the ambient dose rate is so low that a statistically significant value was not obtained, the RSI will be increased to 4 s. The PD(E)-4 will continue to increase the length of

the RSI until it satisfies its internal, statistical criteria or until it reaches the maximum RSI length of 1024 s.

During an RSI, the total number of counts accumulated since the beginning of the RSI is tested at each DSP. If this count exceeds the internal maximum count limit for the given RSI, the PD(E)-4 posts an approximation of the count rate based on the count limit and the current RSI length. It then reduces the RSI length and begins acquiring a new rate sample. The following example illustrates how the PD(E)-4 would react to a step increase in dose rate as might occur when a worker moves into a controlled zone (please refer to Fig. 4-2).

SITUATION: A worker is using an SAIC PD(E)-4 which is already in RATE MODE. He has been working in an area where the background radiation levels are normal so the PD(E)-4 is operating with an RSI of 1024 s. The user then enters an area where the dose rate is 1 R/h. How long will it take for the PD(E)-4 to respond?

RESPONSE: 1 R/h corresponds to approximately 200 cnts/s. It will therefore take at most .32 s to accumulate the 64 counts required to trigger a decrease of the RSI (see Fig. 4-2) at which time the PD(E)-4 computes and displays a RATE estimate based on $\frac{64 \text{ cnts}}{1024 \text{ s}} \approx 320 \mu\text{R/h}$. The PD(E)-4 then decreases the RSI to 64 s and begins the 64 s acquisition. The count will exceed 256 in 1.28 s at which time the PD(E)-4 computes and displays a RATE estimate based on $\frac{256 \text{ cnts}}{64 \text{ s}} \approx 20 \text{ mR/h}$, decreases the RSI to 4 s and begins the 4 s acquisition. After 4 s, the PD(E)-4 computes a true rate of $\approx 800 \text{ cnts/4 s}$ (within the limits of statistics) and displays $\approx 1 \text{ R/h}$. Since the count rate during the 4 s RSI does not exceed 1024, the RSI is maintained at four seconds.

RATE display mode can be totally disabled by setting the appropriate bit in the PD(E)-4's EEPROM in which case successive closures of the MODE button will cause the PD-4™ to advance directly from DOSE mode to CONFIRMATION mode.

4.2.3 Confirmation Mode

Confirmation Mode displays alarm and chirp settings for all active sensors and then generates an LCD (Liquid Crystal Display) test pattern. Upon entering Confirmation mode, a PD-4™ first displays the DOSE alarm value (indicated by a visible DOSE icon) followed by the RATE alarm value (indicated by a visible RATE icon) followed by the CHIRP dose increment value (indicated by a visible Gamma icon). All LCD segments are then turned on simultaneously for the test pattern to allow visual verification that no segments are missing. The user should verify the presence of all seven segments of each of the three digits; the three decimal points; the Dose, Rate, Battery, and Gamma icons; the 'm', 'R', and '/h' icons; and the "EXT" and '1'-2'-3'-4' icons (see Fig. 4-4). Upon completion of the display test, the PD-4™ automatically returns to Dose mode. Pressing the MODE button at any time during execution of Confirmation mode will immediately return the PD-4™ to Dose mode.

Confirmation mode for a PDE-4™ is the same except that before the display test, the DOSE-RATE-CHIRP display sequence is executed for each external probe that is attached. The applicable sensor is indicated on the LCD by a combination of the EXT icon and the 1-2-3-4 icons.

4.2.4 Chirp Increment

The dose increment chirp is a feature rather than a mode. Each time the total dose accumulator increases by a preset increment (the CHIRP dose increment), a brief tone or "chirp" is issued from the audio annunciator. For example, if the chirp increment were set to 20 mR, then each time the PD-4™ accumulated 20 mR of dose, no matter what the rate, a chirp would be announced. As the unit is moved into higher radiation fields, the time between chirps would decrease. This feature gives an audible indication that the field is increasing even if none of the alarm setpoints have been exceeded. Setting the chirp increment to a relatively low value in the 10 to 20 μ R range provides a sensitive audible ratemeter. Even in fields as low as 36 mR/h, the PD-4™ would chirp about once each second. Since the PD-4™ can chirp at most once each DSP (0.75 s), chirp rate is not linear with dose rate under high dose rate and low chirp increment conditions. The Audio Chirp function can be disabled through the PD-4™ EEPROM editing utility function of the PDR application program (See Section 5.1).

In a PDE-4™ which is fully equipped with four external probes, chirp requests from all five sensors will be logically "ORed" together. Therefore, if all five sensors are immersed in the same radiation field, the chirp rate will be five times higher than with a PD-4™. Chirping can be totally disabled by setting the appropriate bit in the PD(E)-4's EEPROM.

4.2.5 Gamma Icon

The Gamma icon, on the far right of the LCD, is turned on for one DSP each time a photon is detected. As with the PDE-4™ chirp feature, photon events from all PDE-4™ sensors are "ORed" together. Hence, in the case of the PDE-4™, activation of the Gamma icon indicates that a photon was detected either by the internal sensor or by one of the attached external probes. At very low dose rates, the Gamma icon will appear to flash and, at dose rates in excess of 10 mR/h, it will be visible nearly continuously.

4.3 Alarms

PD(E)-4 alarms arise either as the result of a radiation measurement, as the result of a change in communication status, or as the result of a change in the supply voltage.

4.3.1 Dose and Rate Alarms

Radiation-related alarms activate both audible and visible indicators when the alarm value is reached or exceeded. When the total accumulated dose alarm setpoint is exceeded, the "DOSE" icon flashes on the LCD and the audio annunciator is activated. Similarly, when the rate alarm setpoint is exceeded, the "RATE" icon flashes and the annunciator is activated. Radiation alarms can be acknowledged (silenced) by pressing the MODE button. Rate alarms will also self-acknowledge when the associated sensor is moved into a radiation field below the rate alarm setpoint. Multiple dose and rate alarms will require multiple closures of the MODE button until each has been acknowledged. Both DOSE and RATE alarms can be individually and totally disabled by setting the appropriate bits in the PD(E)-4's EEPROM.

4.3.2 Failed GMT, Failed HVPS and PDE-4 Probe Disconnect Alarms

The PD(E)-4 constantly monitors a number of internal functions and notifies the user by way of an audio alarm when one of these functions is abnormal. These alarms can all be acknowledged by pressing the MODE button and include the following:

- 1) Failed GMT - If no GMT counts are detected from any internal or attached external radiation sensor within a user-selectable time interval, the Failed GMT alarm is activated. The interval is set in units of 1024 s and would typically be set to a value in the 1 to 5 range.
- 2) Failed HVPS - If the High Voltage Power Supply is no longer able to maintain the factory set high voltage on the anodes of the GMTs, the Failed HVPS alarm is activated.
- 3) Probe Disconnect - If a previously connected PDE-4™ external probe is disconnected during operation, the Probe Disconnect alarm is activated. After acknowledging the alarm, the probe can be reconnected (the PDE-4™ will acknowledge proper connection with a chirp). Note, however, that the recommended procedure for attaching external sensors is to power the PDE-4™ down first. This eliminates the possibility of accumulating false counts as the high voltage connection is made.

4.3.3 Communication Alarms

The Lost Communication Alarm and the Attention/Call alarm can be acknowledged (silenced) by pressing the red CALL button toward the rear of the PD(E)-4. The Attention/Call alarm results from reception of the 'C'- command from the Base Station (or a Repeater) and causes the audio annunciator to be activated. It is intended to initiate a pre-planned procedure such as one of the following:

- 1) Worker immediately abandons his task and leaves the area.
- 2) Worker abandons primary task and moves on to secondary task.
- 3) Worker contacts Base Station operator (using telephone or portable voice radio link).

Acknowledgment of the Attention/Call alarm not only silences the alarm but also results in the immediate transmission of a standard data message with the Attention/Call-bit of the message's status byte set. Thus, the Base Station operator can be assured not only that the 'C'-command was received by the intended PD(E)-4 target but also that it was noticed by the worker.

The Attention/Call command/message sequence can also be reversed. That is, the worker can press his CALL button first to get the attention of the Base Station operator.

The Lost Communication Alarm is activated whenever a Remote's transmission is not acknowledged by its intended recipient. The audio alarm will continue until acknowledged by

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depressing the CALL button or by re-establishing the communication link. When the transmission link is re-established, the Lost Communication Alarm is re-enabled allowing for additional alarms if the link is subsequently broken again. Typical causes of the Lost Communication Alarm include the following:

- 1) The Remote temporarily moves out of range of its Base Station (or Repeater) due either to excessive distance or interfering structures.
- 2) Communications were already marginal and the worker turns around such that his body is interposed between his transmitter and the Base Station (or Repeater).
- 3) The transmitter's RF output stage is powered directly from the battery, but is limited to 7V. As the battery voltage drops below 7V with use, the range will decrease slightly.

The lost communication alarm can be totally disabled by clearing the appropriate bit in the PD(E)-4's EEPROM from the PDR-1(/S)TM Reader.

4.3.4 LEADS and Audio Alarms (General)

There are three Light Emitting Diodes on the front panel of the PD(E)-4 labeled "AT" (Attention/Call), "RD" (Ready), and "CD" (Carrier Detect). Electrically, the AT-LED is in parallel with the audio alarm and will be illuminated whenever the audio alarm is active which includes the following situations:

- 1) Powerup reset chirp (also occurs following a PDR-1TM write operation)
- 2) An unacknowledged dose alarm
- 3) An unacknowledged rate alarm
- 4) An unacknowledged CALL from the Base Station
- 5) An unacknowledged failed sensor alarm
- 6) A failed high voltage power supply alarm
- 7) An unacknowledged PDE-4TM external probe disconnect alarm
- 8) Lost radio communication
- 9) A dose increment chirp
- 10) Display mode change
- 11) Low battery warning (issued only once as a short series of chirps when the low battery detection threshold is crossed)

The RD-LED is illuminated when the PD(E)-4's microprocessor wakes up the radio modem in preparation for transmission of a data message. It is extinguished just before the modem is powered down. Illumination of the CD-LED indicates that the modem's receiver has detected radio carrier. It will flash at least once per transmission interval when the PD(E)-4's messages are being received and acknowledged by a PDX-4TM RadBase or a Repeater. It may flash several times if multiple PD(E)-4 units are operating in the same vicinity on the same radio channel.

4.3.5 Battery Voltage Thresholds

The PD(E)-4 constantly monitors the terminal voltage of its power source. If the supply voltage dips below 6.53 V (the nominal low battery voltage threshold), the battery display icon begins to blink and a short burst of chirps is emitted from the audio annunciator (no acknowledgment is necessary). If the supply voltage dips below 6.03 V (the nominal shutdown voltage), the PD(E)-4 disconnects power from most of its internal circuitry (to prevent operation at subnormal supply voltage) and crowbars a load resistor across the battery terminals to complete the battery discharge process. This mechanism prevents the battery voltage from rising under a no-load condition to a level where the PD(E)-4 would attempt to re-initiate the powerup process.

Crossing of the 6.53 V threshold also starts the "Xmit on Lo-Bat" timer (see Section 5.1, Item 'i'). If this timer expires before the 6.03 V threshold is crossed, the battery icon will become solid, indicating that the PD(E)-4 is still operating as a personal dosimeter with no radio communications.

4.4 Display Backlight

The PD(E)-4 includes a display backlight to enhance readability under subdued lighting conditions. It can be activated by pressing the black Backlight button located behind the MODE button.

4.5 External Audio Output Specification

The output from the PD(E)-4's external audio jack (when active) is an AC-coupled, 5 V peak-to-peak square wave of approximately 2.5 kHz. Its output impedance is approximately 3.3 k Ω resistive.

4.6 Higher Gain Directional Antennas

In some situations, communication range can be increased by replacing the SAIC supplied omnidirectional antennas with directional antennas which increase range by decreasing solid angular coverage. For instance, if all Remotes and Repeaters are located north of their RadBase, then RF power radiated by the RadBase in the southerly direction is wasted. In this particular case, it would make sense to employ a directional antenna which concentrates most of its radiated RF power toward the North, thus increasing the RadBase-to-Remote range. The gain provided by a directional antenna is equally effective when the RadBase is receiving, so the Remote-to-RadBase range is also increased. It is not difficult to imagine network situations where directional antennas could be advantageously used with Repeaters as well.

The use of directional antennas with Remotes could easily cause some problems since communications would be lost each time the worker turned his blind spot toward the RadBase. However, when Remotes are used as stationary area monitors, the directional antenna can provide a distinct performance improvement.

IMPORTANT:

Maximum legal antenna gain is set by the Federal Communications Commission. Before choosing a higher gain, directional antenna, be sure that it conforms to current FCC regulations.

4.7 Power Sources for the PD(E)-4

The PD(E)-4 may be powered by several sources including a 9 V internal alkaline battery, an external battery pack, or an external 9 Vdc power adaptor (i.e., a device that plugs into a standard 120 VAC outlet and consists of a stepdown transformer followed by rectifiers and a 9 Vdc regulator). The SAIC supplied adaptor is a good example of the latter.

CAUTION:

Before applying external power to a PD(E)-4, be sure you are using a 9 V device which applies negative polarity to the center conductor of the connector. Please note that the 9 V adaptor supplied for the PDX-4™ RadBase is of the opposite polarity.

Whatever power source is used should have a source impedance no greater than 3.0 Ω with less than 100 mV of open circuit ripple at its output terminals. Its open circuit DC output voltage must lie in the range from 7.5 to 9.5 V. The higher supply voltages will provide somewhat greater communication ranges.

To install a new battery, first insure that the power switch is in the "Off" position and then turn the PD(E)-4 upside down and open the battery well by pushing the battery well cover toward the rear of the instrument. Remove the polarized battery connector from the old battery (if present) and snap it onto the new battery. Wind the extra battery lead around the battery terminals as shown in Fig. 4-3 and drop the battery into the well. Snap the battery well cover back into place.

Before the PD(E)-4 applies power to its internal logic circuitry, it first tests the suitability of the power source by performing a load test. If the power source fails the test (e.g., the open circuit voltage is OK but the source impedance is too high), the PD(E)-4 will not initiate its powerup reset sequence. Attempts to operate PD(E)-4s with discharged or nearly discharged batteries will result in this type of behavior.

IMPORTANT:

If the power switch is in the "On" position when a power source is connected, it is probable that contact bounce will cause PD(E)-4 built-in test circuitry to disengage the main voltage regulator from the power source (there will be no powerup chirp and the display will remain blank). If this happens, turn the unit off for a few seconds using the power switch and then try again.

4.8 Power Consumption and Battery Life

The recommended portable power source for the PD(E)-4 is a Duracell 9 V alkaline battery. Battery manufacturers typically rate the capacity of their 9 V alkalines near 500 mA•h (1800 Coulombs). However, the PD(E)-4 does not discharge its battery at the optimal rate nor can it discharge its battery to the assumed end-of-life voltage so it is more realistic to assume a usable capacity of about 350 mA•h (1260 Coulombs).

The steady-state load current of the PD(E)-4 is about 10 mA. This is the current required to run all the logic including the microprocessor and to generate the high voltage required for biasing the GMTs. Each message transmitted by the PD(E)-4 drains about 60 mC of charge from the battery so the total average load current is $10 \text{ mA} + 60 \text{ mC}/T$ where T is the interval between transmitted messages in seconds. The expected battery life is therefore given by

$$\text{Battery Life} \approx \frac{350 \text{ mA}\cdot\text{h}}{(10 + 60/T) \text{ mA}} \text{ hours.}$$

The relation above shows that for $T > 60 \text{ s}$, the expected battery life is about 35 hours; for $T = 6 \text{ s}$, it is about 17 hours; and for T set to the minimum transmission interval of 2 s, the expected life drops to about 9 hours. This curve is plotted in Fig. 4-4. Activation of the backlight or audio alarm will reduce these projections and, of course, the more active these devices are, the greater the reduction.

A good operational strategy is to match the transmission interval to the task requirements and not require the PD(E)-4 to transmit more data than is necessary. For instance, the interval between transmissions might be set to 30 or even 60 seconds while a worker is being instrumented; this suffices to demonstrate the viability of the communication link. The transmission interval can then be decreased after entry to the work zone to provide a time response that is appropriate for the task.

Another important consideration is peak instantaneous load current. Since the source impedance of a 9 V alkaline battery is 2 to 5 Ω depending on its discharge state, the battery's output voltage drops lower as the load current increases. The peak current demand during a communication cycle can go as high as 300 mA for the few milliseconds that are required to actually transmit a message. Therefore, during these few milliseconds, the battery voltage can dip 600 to 1500 mV. Since even momentary excursions of the battery voltage below safe operating levels are unacceptable, the PD(E)-4's voltage threshold detectors are designed to respond to these transients. This explains why attempts to measure the low voltage threshold or the shutdown voltage with an averaging voltmeter such as a DVM give erroneously high results (an oscilloscope can be used for these measurements). This also explains why some brands of batteries with higher source impedances cannot provide expected operating lifetimes: the voltage dips below the low voltage and shutdown thresholds long before the 350 mA•h of charge have

been consumed. Battery impedance effects are indicated on the typical battery discharge curve shown in Fig. 4-6.

Longer battery lives will be obtained by using longer transmission intervals and by minimizing peak instantaneous load currents. Several options have been provided to assist the user in accomplishing the latter. For example, the user can choose to have the audio annunciator automatically disabled whenever the radio modem is powered. This guarantees that both devices cannot simultaneously draw current and hence minimizes negative battery voltage excursions. Similarly, the user can opt to have the audio annunciator totally disabled after the low battery threshold is crossed.

It is interesting to note the fractional breakdown of the message charge requirements. Very roughly, only about 5 mC of the 60 mC message charge is involved with the message transmission. The remainder is consumed while the radio modem is settling following application of power and by the receiver while it is waiting for commands from the Base Station. Thus, the price of bidirectional communications is not insignificant but neither are the additional capabilities.

Battery life can also be affected by the total number of operating PD(E)-4s that are within radio range. Each time a PD(E)-4 Remote receives a message (which must be on the same radio channel and subchannel), its time-to-radio-receiver-shutdown is delayed by 0.25 seconds. This is done so the Base Station can hold the attention of up to sixteen attached units without one powering down its receiver while the Base Station is talking to the others. Battery life can be decreased by up to 50% in large networks (10 to 16 units) using short transmission intervals (2 to 10 seconds).

4.9 Battery Life and ANSI N13.27

In order to meet the requirements of ANSI N13.27A, paragraph 3.2.2 for power reserve, an alarming dosimeter must operate for at least eight hours in a 100 mR/h field after initial indication of low battery voltage. The PD(E)-4 is able to meet this requirement by terminating communications at the expiration of a user-adjustable interval following detection of low battery voltage (hence, removing a major portion of the electrical load). This communication interval following detection of low battery voltage should not exceed ten minutes to ensure the full eight hours of operation as an alarming dosimeter.

Users who do not require the PD(E)-4 to continue operation as the principal alarming dosimeter can set the post-low-battery communication interval to its maximum value of 136 minutes.

4.10 Handling and Cleaning Procedures

In use, the PD(E)-4 has proven itself to be reasonably rugged. They have repeatedly survived drops of several feet onto tabletops and carpeted floors. However, SAIC considers the probability for surviving a one to two meter drop onto concrete to be low (compared to the survival probabilities for their smaller non-radio counterparts like the PD-1™ and PD-3™). A good handling policy is to treat the PD(E)-4 like a palmtop PC; don't baby it, but don't abuse it either.

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SAIC recommends that the original packing materials be saved in the event that it becomes necessary to return the PD(E)-4 to the factory.

The PD(E)-4 case has been designed for easy decontamination. Should it become necessary to perform any sort of cleaning procedure, note the following points:

- 1) The PD(E)-4 is not immersion-proof. If necessary, the PD(E)-4 may be wiped down with a damp cloth.
- 2) Never use any organic solvents on the PD(E)-4. If absolutely necessary, use a dilute solution of a mild detergent (e.g., liquid dishwashing detergent) to dampen the cloth.

5.0 PD(E)-4 EEPROM EDITING

A large portion of the PD(E)-4's personality is determined by the firmware in its One-Time Programmable (OTP) microprocessor and cannot be revised without physically changing the processor chip. The remainder of its personality is controlled by values stored in its Electrically Erasable Programmable Read Only Memory (EEPROM). PD-4™ values which control its radiation and communication performance can be edited using a PDR-1™ Reader in conjunction with Option 'A' (EDIT) of SAIC's DOS application, PDRC4. Similarly, values associated with the radiation performance of external sensors of a PDE-4™ can be edited with Option 'B' (EDITX) of PDRC4. The edit screens are shown below with alphabetic characters on the left and right sides of the screens to identify the items that are accessible with the edit controls [numbered items are data generated by the PD(E)-4].

5.1 PDRC4 Option 'A' (EDIT)

Option 'A' is a read-edit-write utility which allows the user to modify the contents of the EEPROM without having to understand the details of PD(E)-4 variable structures. This routine translates the results of the read operation into engineering units for easy editing and then re-translates the modifications back to PD(E)-4 formats prior to the write operation. Option 'A' permits editing of all PD(E)-4 EEPROM values except those associated with PDE-4™ external probes (this latter function is performed by Option 'B'). A number of these options are related to characterization of the radio link and usually will not need to be changed from the factory defaults. These menu items are starred (*) in the display screen representation below; improper or inconsistent values for these parameters will disable communications between PD(E)4-s and PDX-4 RadBases.

PD-4 EEPROM EDITING UTILITY

a	ZERO Date: 23-MAR-94	BKGD Cor1 (c/1024s): 6	u
b	ZERO Time: 13:09:18	DOSE Cal2 (R/cnt): 1.35 μ	v
c	User ID String: ' SAIC '	GMT Dead Time2 (s): 15.7 μ	w
	(or numeric) : 3732492916	BKGD Cor2 (c/1024s): 0	x
d	* Control Group: CG00000	Time>RATE Alr1 (m): 0.00	1
e	* Broadcast Address: FFFFFFFF	Time>RATE Alr2 (m): 0.00	2
f	* Radio Channel: 4	Total DOSE1 (R): 2.32 m	3
g	* Radio Sub-channel: 1	Total DOSE2 (R): 0.00	4
h	Transmit Int (s): 10.0	Peak RATE1 (R/h): 2.42 m	5
i	Xmit on Lo-Bat (m): 5.00	Peak RATE2 (R/h): 0.00	6
j	GMT Alarm (1024 s): 2	Factory Serial No: RT01013	
k	Dose Alarm1 (R): 1.00	Options:	
l	RATE Alarm1 (R/h): 10.0	Audio RATE Alarm	A
m	CHIRP Inc1 (R): 10.0 m	RATE Mode	B
n	DOSE Alarm2 (R): 1.00	Repeater Mode	C
o	RATE Alarm2 (R/h): 10.0	Audio DOSE Alarm	D
p	CHIRP Inc2 (R): 10.0 m	Audio CHIRP	E
q	CAL Date: 07-JAN-94	LOST Comm Alarm	F
r	CAL Time: 17:23:12	Transmission Mode	G
s	DOSE Call (R/cnt): 1.34 μ	Audio during Comm	H
t	GMT Dead Time1 (s): 20.0 μ	Audio during Lo-Bat	I

- a) "ZERO Date" is updated each time the PD(E)-4 is reset by a PDR-1™ either by pushing the DOSE RESET button of the PDR-1™ or by sending a reset command to the PDR-1™ from the host PC. The date is obtained from the PDR-1's™ internal clock/calendar which may be set using PDRC4's Option 'W' (DATIM).
- b) "ZERO Time" is updated with "ZERO Date" and is also obtained from the PDR-1's™ internal clock/calendar.
- c) "User ID String" consists of two, consecutive 16-bit registers into which the user may enter either an alphanumeric, 6-character string or a 10-digit numeric value. If the string option is chosen, the legal character set consists of capitol letters (A-Z), numeric digits (0-9), and the four characters ' ', '#', '*', and '!'. If the alphanumeric interpretation of the User ID String doesn't seem to make any sense, then most likely this data was entered numerically (e.g., a social security number). The performance of a PD(E)-4 is not affected in any way by the contents of the User ID registers.
- d) "Control Group" (also called Communication Group) is one of a group of message filters that a PD(E)-4 uses to determine when it is the intended target for a received message. Every message packet transmitted by a PD(E)-4 or PDX-4™ RadBase contains a Control Group number which the receiving unit compares to its EEPROM Control Group number. If a match is obtained, the receiving unit will respond to the message; otherwise, the message is ignored. Other message filters include the radio channel and radio subchannel; in general, these latter two filters are preferable because they don't involve any microprocessor overhead to process messages simply so they can be ignored. The majority

of network requirements can be met by leaving the Control Group at its factory default value of CG00000.

- e) The "Broadcast Address" is used to select target(s) for a transmitted message. The factory default value of FFFFFFFFH is a general broadcast address to all receivers that are within range and that are set to the same radio channel and subchannel. Transmissions can be directed to a specific target receiver by inserting the factory serial number of the desired target's radio modem into the Broadcast Address. For example, if the modem serial number is 31104, then the decimal number, 31104, should be inserted for the Broadcast Address. Alternatively, the value could also be inserted using its hexadecimal equivalent, 7980H. The use of any value other than the general broadcast address will disable the ability to re-acquire a new target if communications are lost (See item J).
- f) "Radio Channel" is a single digit ($1 \leq \text{Channel} \leq 7$) which sets radio transmission and reception to one of seven different radio channels lying within the frequency range from 902 to 928 MHz. Radio modems which are expected to communicate with each other must be set to the same radio channel. Radio channels 1, 4, and 7 are non-overlapping which means that radio traffic generated by a network operating on one of these channels does not constitute radio traffic for the other two non-overlapping channels. Radio Channel is the primary message filter in the sense that receivers set to a different radio channel from the transmitter are not even aware that a message was sent; hence, there is no computing overhead associated with this filter as there is in the case of the Control Group and there is no potential for message collisions (simultaneous transmissions resulting in garbled messages). PD(E)-4 radio modems incorporate collision avoidance algorithms but communications will be most reliable when the need for collision avoidance is minimal.
- g) "Radio Sub-channel" is yet one more way to filter messages. Separate networks may be established on the same radio channel if each network uses a different subchannel ($1 \leq \text{Sub-channel} \leq 65535$). The computing overhead associated with Sub-channel message filtering is intermediate between Radio Channel filtering and Control Group filtering. All receivers operating on the same channel as the transmitter will receive the message for processing by the radio modem's local microprocessor. However, if the subchannels don't match, the message will not be passed on to the host microprocessor (i.e., there will be no RS232 activity). It follows that transmissions from different networks operating on the same channel but different subchannels can collide which leaves Radio Channel filtering as the best method for setting up multiple, non-interacting networks.
- h) "Transmit Int" is the interval between successive radio transmissions in seconds. To extend battery life, the PD(E)-4's radio modem is powered down after each message transmission. After the period of time in seconds, defined by Transmit Int has passed, the PD(E)-4 reapplies power to its modem, allows the modem to settle, and then transmits its data message. During the next 250 ms interval, it listens for radio messages. If a message is received, the PD(E)-4 responds appropriately (e.g., changes an alarm value, initiates a CALL alarm, etc.) and then powers down the modem. If no messages are received, the modem is powered down immediately.

- i) "Xmit on Lo-Bat" is the length of the time interval (in minutes) during which the PD(E)-4 will continue with normal radio communications after it detects a low battery voltage condition. **At the end of this interval, the PD(E)-4 will continue to operate as a personal dosimeter with no radio functions.** Battery threshold levels have been set to provide at least eight hours of operation if the Xmit on Lo-Bat value does not exceed 10 minutes (based on an originally fresh, 9 V alkaline battery). Because the electrical load of the radio modem is relatively high compared to the balance of the PD(E)-4's circuitry, the remaining battery life drops rapidly as the Xmit on Lo-Bat value is increased.
- j) "GMT Alarm" is the time interval (in units of 1024 seconds) after which the PD(E)-4 initiates a failed GMT alarm if no GMT counts are detected. From one standpoint, this value should be set low to minimize the amount of time that a failed GMT goes undetected. However, lower values for GMT Alarm increase the false alarm rate. For example, the internal GMT of a PD(E)-4 generates about 35 counts/hour at background. The probability that it won't generate a count in 1024 s is $\exp(-35 \cdot 1024 / 3600) = 0.0000475$. Therefore, the probability that it won't generate a false alarm in 1024 s is $(1 - 0.0000475) = 0.9999525$ and the probability that it won't generate a false alarm in one day is $0.9999525^{(24 \cdot 3600 / 1024)} \approx 0.9960$. Thus, there is about a 0.4% probability that a false alarm will be generated during any 24 hour period of operation. GMTs used in PD(E)-4 external probes generate only about 16 counts/hour at background so the probability for one false alarm per day rises to about 59%. If all four external probes are used for a full day, the probability is $[1 - (1 - 0.59)^4] \approx 97\%$ that at least one of the probes will false alarm (if GMT Alarm = 1). This false alarm rate drastically drops if GMT Alarm is set to 2, 3, 4, or 5 to 2%, 0.01%, 0.0001%, and 0.000001%, respectively. When the PD(E)-4 is used in radiation fields of 100 $\mu\text{R/h}$ or more, the probability for false alarms drops to essentially zero. GMT Alarm values equal or greater than 2 are preferable.
- k) "DOSE Alarm1" is the dose alarm value for Internal GMT #1 in R (i.e., a GMT that is built into the PD(E)-4 which would measure trunk or whole body dose in cases where the PD(E)-4 is worn on the back or chest).
- l) "RATE Alarm1" is the dose rate alarm value for Internal GMT #1 in R/h.
- m) "CHIRP Inc1" is the dose increment between audible chirps for Internal GMT #1 in R.
- n) "DOSE Alarm2" may eventually be the dose alarm value for Internal GMT #2 in R. SAIC does not currently install GMT #2 although the physical space, the pulse counter, and the required firmware hooks are already incorporated in the PD(E)-4 design. This is essentially an expansion slot for an additional detector such as an uncompensated GMT to measure shallow dose. The value will not currently affect PD(E)-4 operation.
- o) "RATE Alarm2" -- Not currently used.
- p) "CHIRP Inc2" -- Not currently used.

- q) "CAL Date" is the date of the most recent calibration operation. Options 'M' and 'N' (LCAL and DCAL) of PDRC4 will automatically update the CAL Date using a value obtained from the PDR-1's™ clock/calendar.
- r) "CAL Time" is the time of the most recent calibration operation. Options M and N of PDRC4 (LCAL and DCAL) will automatically update the CAL Time using a value obtained from the PDR-1's™ clock/calendar.
- s) "DOSE Cal1" is the linear calibration factor for Internal GMT #1 in $\mu\text{R}/\text{count}$. This is the scaling factor used to convert counts detected by GMT #1 to dose values in μR (by multiplication). Option 'M' of PDRC4 (LCAL) will compute and install a new value for DOSE Cal1 based on the application of a known dose increment to the PD(E)-4.
- t) "GMT Dead Time1" is the effective time interval in μs that Internal GMT #1 is dead (unable to respond to radiation) following a Geiger avalanche. Measured dose increments and dose rates are corrected by the factor, $1/(1-C\tau)$ where C is the measured GMT counting rate and τ is the GMT Dead Time. Option 'N' of PDRC4 (DCAL) will compute and install a new value for GMT Dead Time1 based on the application of a known dose increment at a known rate to the PD(E)-4.
- u) "BKGD Cor1" is the spontaneous count rate (in units of counts/1024 s) generated by Internal GMT #1. This includes all counts that are not related to the ambient radiation field such as counts generated by decay of radioactive isotopes in the GMT's structural materials. BKGD Cor1 is used to correct both dose and dose rate values. The dose correction can be significant if the PD(E)-4 is operated continuously at background radiation levels.
- v) "DOSE Cal2" -- Not currently used.
- w) "GMT Dead Time2" -- Not currently used.
- x) "BKGD Cor2" -- Not currently used.
- 1) "Time>RATE Alr1" is the total integrated time in minutes since the last PD(E)-4 reset operation that Internal GMT #1 measured a dose rate in excess of the RATE Alarm1 value (this item is not subject to editing).
- 2) "Time>RATE Alr2" -- Not currently used.
- 3) "Total DOSE1" is the total accumulated dose in R measured by Internal GMT #1 since the last reset operation (this item is not subject to editing).
- 4) "Total DOSE2" -- Not currently used.
- 5) "Peak RATE1" is the maximum dose rate measured by Internal GMT #1 since the last reset operation (this item is not subject to editing).

- 6) "Peak RATE2" -- Not currently used.
- A) "Audio RATE Alarm" enables or disables the PD(E)-4's audio response to a rate alarm. Users might wish to disable this response in cases where they expect to be in a field that exceeds the rate alarm value and are more interested in audible dose alarms.
- B) "RATE Mode" enables or disables the rate display mode of the PD(E)-4. Disabling this option does not disable the audio rate alarm function.
- C) "Repeater Mode" enables or disables the PD(E)-4 repeater mode. When this option is enabled, the PD(E)-4 will appear to power up normally. After acquiring a Base Station or another repeater, the letters "rPr" will appear on its LCD, indicating that it has switched to repeater mode and is capable of retransmitting messages to the acquired target. When a PD(E)-4 enters repeater mode, it is fully dedicated to the repeater task and performs no radiological functions. A repeater is returned to normal (remote) mode by turning it off, waiting a few seconds, turning it back on, and then disabling the Repeater Mode option using a PDR-1™ with PDRC4. This operation can be frustrating when performed within range of operating Base Stations or Repeaters since the PD(E)-4 will always attempt to acquire a target on powerup and won't communicate with PDR-1s™ after entering repeater mode. In these cases, the unit's antenna may be temporarily removed to reduce its range. Alternatively, the Base Stations and Repeaters can be temporarily powered down.
- D) "Audio DOSE Alarm" enables or disables the PD(E)-4's audio response to a dose alarm. Users might wish to disable this response in cases where they expect the dose alarm value to be exceeded and are more interested in audible rate alarms.
- E) "Audio CHIRP" enables or disables the PD(E)-4's audible response to the accumulation of a chirp increment of dose.
- F) "LOST Comm Alarm" enables or disables the PD(E)-4's audible response when its transmissions are not acknowledged by its target Base Station or Repeater. With this option enabled, the PD(E)-4 will generate a continuous alarm beginning with the occurrence of the first unacknowledged transmission and ending with the occurrence of the next acknowledged transmission. The most common causes for LOST Comm Alarms are excessive transmitter-to-receiver distances or excessive amounts of intervening RF attenuators (e.g., metal or reinforced concrete walls). However, as the number of units operating on the same radio channel increases, so will the number of unresolvable message collisions.
- G) "Transmission Mode" was originally intended to allow the user to select between Broadcast and Point-to-Point modes of communication. A useful feature of Broadcast mode is that any receiver operating on the same radio channel and subchannel as the transmitter can receive a Broadcast message. However, in networks containing a repeater, Broadcast mode can cause some very undesirable effects. For example, the Base Station may receive two copies of the same message, one directly from the remote and another from the repeater. In networks containing two or more repeaters, the effects can be even

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worse. The first message transmitted by a remote may be received and repeated by both repeaters; the repeated messages might then be received and repeated by both repeaters, and so on. Though amusing in the laboratory, this kind of operation would be disastrous in the field. Because of the preceding considerations, general Broadcast communications are not supported by SAIC's communication application, RS, and the ability to toggle this option bit has been disabled in SAIC's reader application, PDRC4. User's who are writing their own applications should use Broadcast mode with caution.

- H) "Audio during Comm", when set to DISABLED, disables the audio annunciator during intervals when power is being applied to the radio modem. The purpose of this option is to reduce the maximum instantaneous load that can be applied to the battery and thereby extend the useful battery life. 9 V alkaline batteries typically have a source impedance in the 2 to 5 Ω range. This means that the battery voltage will drop 200 to 500 mV when the PD(E)-4 switches in a load that draws 100 mA (such as the radio receiver). By not allowing simultaneous activation of the annunciator, the negative battery voltage excursions are minimized and crossings of the low battery and shutdown voltage thresholds are delayed. Note, however, that normally continuous audio alarm rhythms will be interrupted for about a second each time the PD(E)-4 transmits a message.
- I) "Audio during Lo-Bat", when set to DISABLED, disables the audio annunciator totally following detection of the low battery voltage condition. As with Item (H), the purpose is to extend battery life. Users must decide whether or not their particular applications allow continued operation with a disabled audio alarm.

PD-4 REPEATER EEPROM EDITING UTILITY

J	Lost-Coms to Re-Acq: 2	Options:	
K	Max Attachments: 10	Auto-'A' Command	ENABLED
L	Max Direct Remotes: 4	Attach Lower FSNs	ENABLED
M	Max Direct Repetr: 2		

- J) "Lost-Coms to Re-Acq" is the maximum number of consecutive, unacknowledged data messages that a PD(E)-4 Remote will transmit before it gives up on its old target and attempts to acquire a new target. For example, a worker might be roaming a large area serviced by multiple Base Stations or Repeaters. As he moves out of range of his current target, he is moving closer to some other Base Station or repeater. Eventually, he moves entirely out of range of the original target and a message is lost (not acknowledged). With Lost-Coms to Re- Acq set to 1, this worker's PD(E)-4 would initiate a general Broadcast probe looking for potential new targets. It would then acquire the first target to acknowledge its Broadcast probe. If Lost-Coms to Re-Acq were set to 3, the PD(E)-4 would wait for the third lost message before initiating the Broadcast probe. Setting Lost-Coms to Re-Acq to zero disables the ability of a Remote to look for new targets; that is, it continues with point-to-point communications to its original target regardless of how many messages are lost.

Items (K) through (O) deal with Repeater Mode Options and will have no effect on Remote Mode Operation.

- K) "Max Attachments" has the same meaning in the present context that it did in the Base Station Setup context [similarly for items (L) and (M) below]. It is the maximum number of units (including both Repeaters and Remotes) that can funnel information through this Repeater (either directly or indirectly).
- L) "Max Direct Remotes" is the maximum number of PD(E)-4 Remote units that can directly attach to this Repeater. Setting this number to zero will force Remote units to attach indirectly through a different Repeater, thus eliminating the possibility of a marginal direct attachment (due to excessive range of the direct attachment).
- M) "Max Direct Repetrs" is the maximum number of direct Repeater attachments that this Repeater will allow. Typically, it would be set to zero when the Repeater is the most distant Repeater in a multiple Repeater network. This would eliminate the possibility of establishing reverse Repeater links (i.e., Repeater links that lead away from the Base Station rather than toward it).
- N) "Auto-'A' Command" enables or disables automatic transmission of the 'A' Command which instructs Remote units to transmit a message packet containing its current Alarm settings (along with some status information). When in Repeater mode, a PD(E)-4 inspects each message that it repeats to a direct Remote attachment to determine if the message will cause a change in any operating parameter (e.g., will it cause an alarm level or the transmit interval to change?). In these cases, the Repeater will automatically append the 'A' command to the transmission. When the target Remote responds, it will append the 'a' message to its data message. The purpose of the Auto-'A' command is to reduce radio traffic; the alternative is for the Base Station to send the 'A' command which must then be repeated by each Repeater in the network.

IMPORTANT:

The SAIC application program, RadStar (RS.EXE), assumes that the Auto-'A' Command option will be enabled in all repeaters of a network (i.e., RS will not sent the 'A'-Command to indirectly connected Remotes). Therefore, if the Auto-'A' option is not enabled in the network Repeaters, RS will never receive the 'a' message from indirectly connected Remotes.

- O) "Attach Lower FSNs" enables or disables the ability of a Repeater to attach other Repeaters and remotes having a Factory Serial Number (e.g., RT01000 or RE01001) whose numerical part has a lower value than its own. The purpose of this option is to provide the user a simple mechanism for avoiding reverse communication links in automatically configured Repeater networks. This can be accomplished by disabling the Attach Lower FSNs option in all Repeaters and then locating them in order of increasing Factory Serial Number away from the Base Station. The Factory Serial Number of a Remote must be higher than the Factory Serial Number of the Repeater it is expected to acquire.

With Attached Lower FSNS enabled, Repeaters pay no attention to Factory Serial Numbers when deciding whether or not to acquire other Repeaters or Remotes (i.e., reverse

communication links carry messages away from, rather than toward the Base Station, are a possibility).

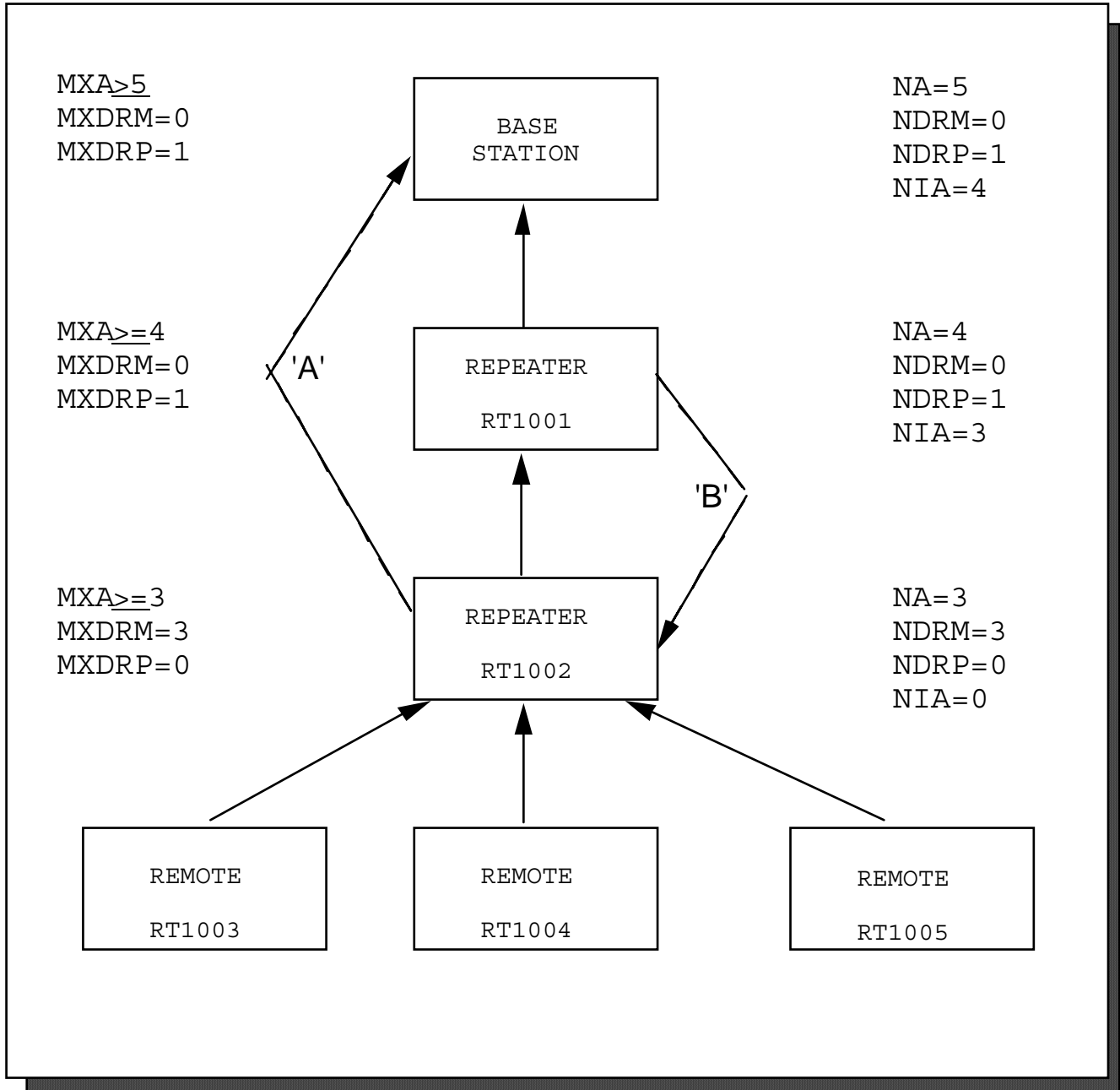
The following diagrams illustrate the use of items K through O in helping to establish the desired network configuration (see Appendix B for more details concerning network configuration). The following abbreviations are used in the diagrams:

RADSTAR SETTINGS

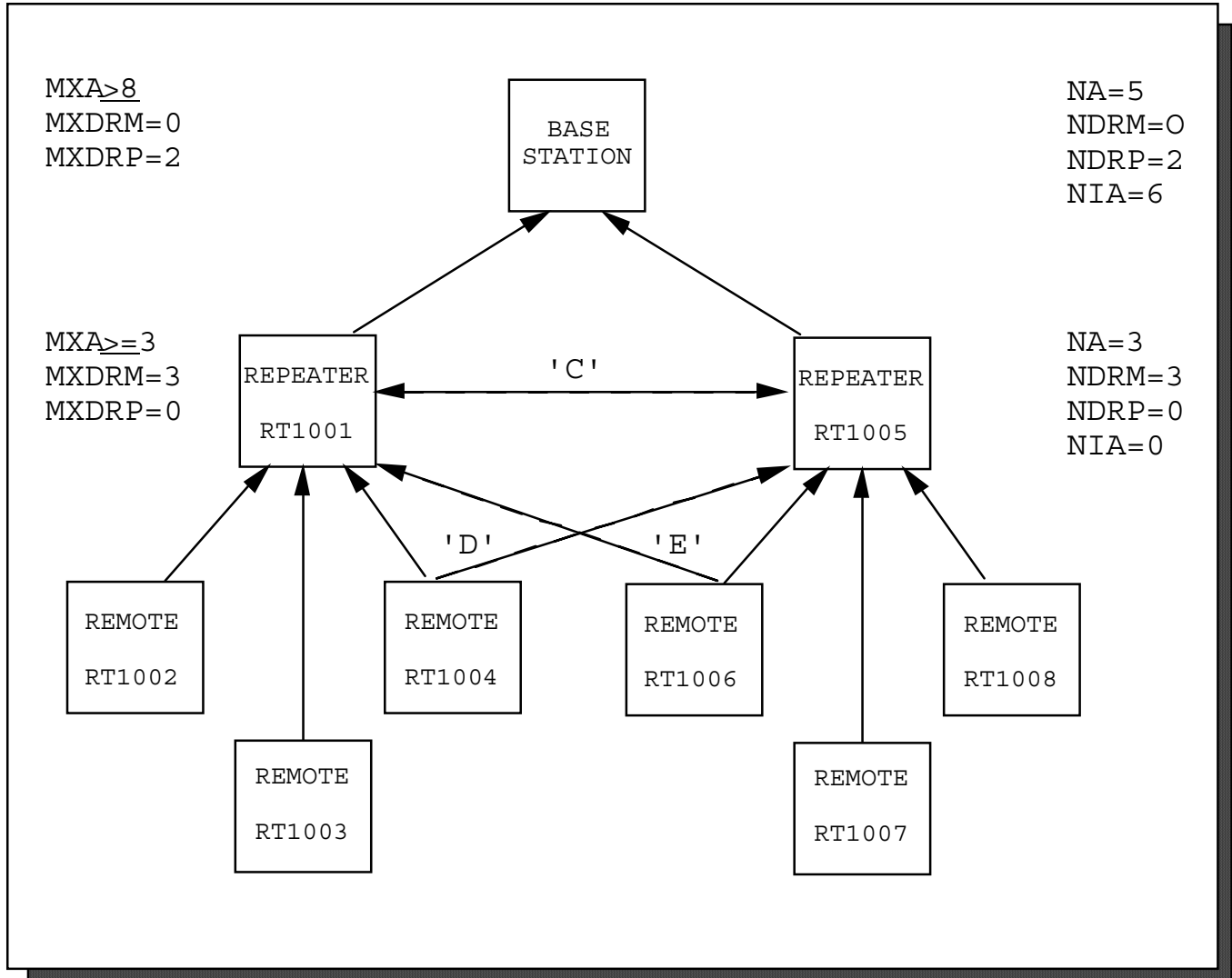
"Max Attachment" = MXA
"Max Direct Remotes" = MXDRM
"Max Direct Repetrs" = MXDRP
"Attach Lower FSNs" = ALF

ACTUAL SYSTEM CONFIGURATION

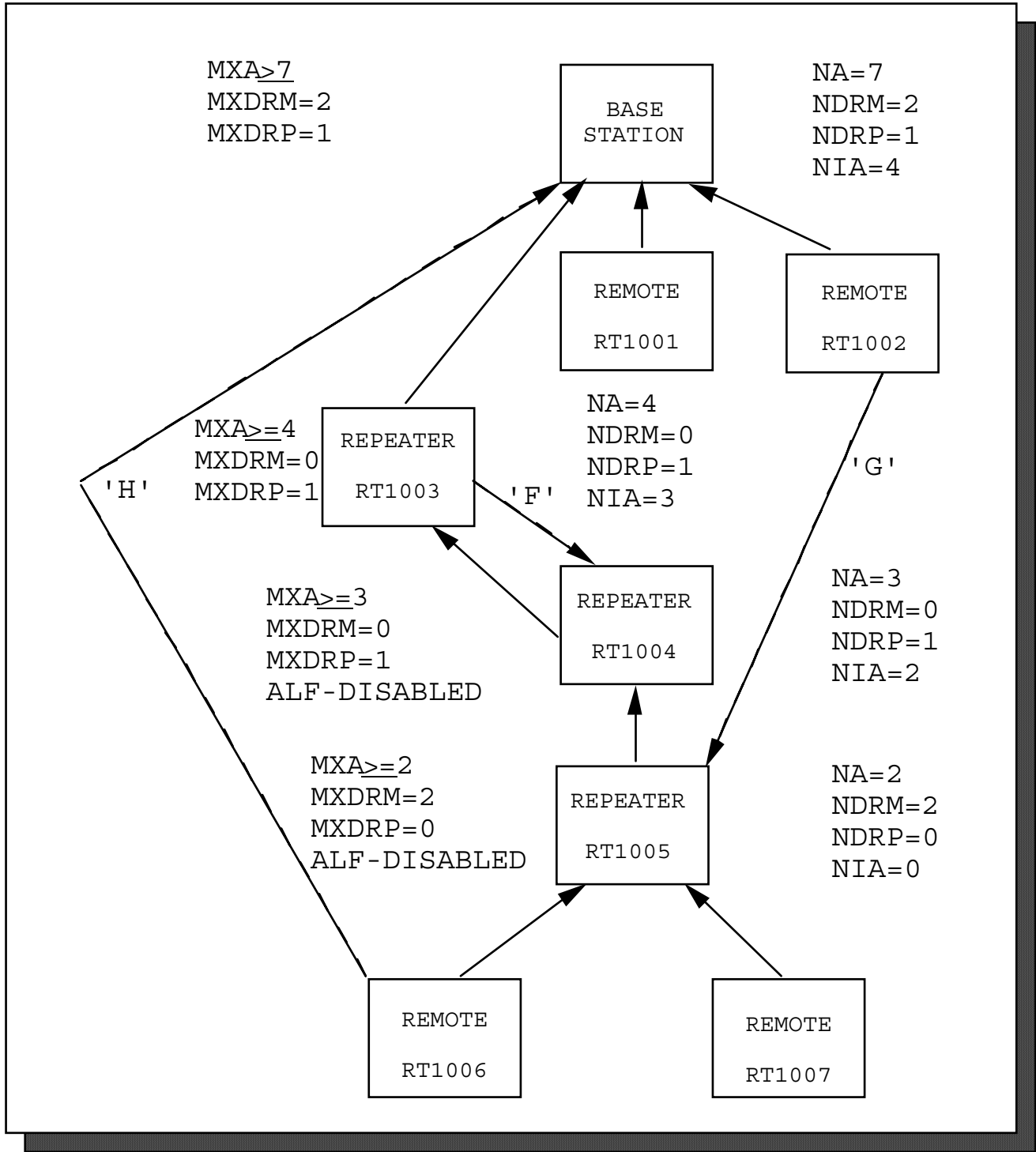
Actual # of Attachments = NA
Actual # of Direct Remotes = NDRM
Actual # of Direct Repeaters = NDRP
Actual # of Indirect Attachments = NIA



An attachment such as link 'A' is potentially possible if RT1002 is within radio range of the Base Station. It cannot be prevented by disabling ALF but it can be prevented by insuring that RT1001 is attached to the Base Station before powering up RT1002. Disabling ALF would prevent a reverse link like "B". However, "B" is also prevented by MXDRP=0 for RT1002 (i.e., RT1002 will not allow other repeaters to attach). In this example, the state of ALF makes no difference.



In this example of a parallel repeater network, it is important to prevent attachments such as link "C". This is accomplished by setting MXDRP=0 in both repeaters. Disabling ALF in the Repeaters guarantees that RT1002-RT1004 won't acquire RT1005 but will not inhibit RT1006-RT1008 from acquiring RT1001 (the network as shown can be achieved by sequentially powering up the units in order of increasing or decreasing serial numbers). A useful variation which permits roving remotes is achieved by enabling ALF and increasing MXA to 6 in both repeaters. This permits connections such as links "D" and "E" when a remote moves out of range of its original Repeater.



In the more complex network of this example, reverse attachments like links “F” and “G” can initially be prevented by powering up the units in order of increasing FSN. However, this does not guarantee that the network won’t reconfigure itself at a later time if the Remotes attempt to acquire due to lost messages; this can be guaranteed by disabling ALF in RT1004 and RT1005. Attachments such as link “H” are presumably not possible due to range considerations (this may also be true of link “G”).

5.2 PDRC4 Option 'B' (EDITX)

Items (P) through (V) and (7) through (9) apply to one of four External Extremity Probes. These values are irrelevant to the operation of a PD-4™. The probe number is indicated near the center of the PDRC4 External Sensor Editing Screen as a digit from 1 through 4 (shown below) which corresponds to External Probe Connectors numbered consecutively from the front to the rear of the PDE-4™.

Option 'B' is a read-edit-write utility (similar to Option 'A') which allows the user to modify the contents of the EEPROM associated with the External GMTs without having to understand the details of PDE-4™ variable structures.

PDE-4™ EXTERNAL SENSOR EEPROM EDITING UTILITY

P	DOSE Alarm (R): 500 m	DOSE Alarm (R): 500 m	P
Q	RATE Alarm(R/h): 1.00	RATE Alarm(R/h): 1.00	Q
R	CHIRP Incrmnt (R): 1.00 m	CHIRP Incrmnt (R): 1.00 m	R
S	Dose Cal (R/cnt): 1.35 μ	Dose Cal (R/cnt): 1.35 μ	S
T	CMT Dead Time (s): 15.7	CMT Dead Time (s): 15.7	T
U	BKGD Corr (c/1024s): 1	BKGD Corr (c/1024s): 1	U
V	Factory Serial No: XS00101	Factory Serial No: XS00103	V
7	Time>RATE Alrm (m): 0.00	Time>RATE Alrm (m): 0.00	7
8	Total DOSE (R): 0.00	Total DOSE (R): 0.00	8
9	Peak RATE (R/h) 0.00 1	3 Peak RATE (R/h): 0.00	9
P	DOSE Alarm (R): 500 m 2	4 DOSE Alarm (R): 500 m	P
Q	RATE Alarm(R/h): 1.00	RATE Alarm(R/h): 1.00	Q
R	CHIRP Incrmnt (R): 1.00 m	CHIRP Incrmnt (R): 1.00 m	R
S	Dose Cal (R/cnt): 1.35 μ	Dose Cal (R/cnt): 1.35 μ	S
T	CMT Dead Time (s): 15.7	CMT Dead Time (s): 15.7	T
U	BKGD Corr (c/1024s): 1	BKGD Corr (c/1024s): 1	U
V	Factory Serial No: XS00102	Factory Serial No: XS00104	V
1	Time>RATE Alrm (m): 0.00	Time>RATE Alrm (m): 0.00	7
2	Total DOSE (R): 0.00	Total DOSE (R): 0.00	8
3	Peak RATE (R/h) 0.00	Peak RATE (R/h) 0.00	9

- P) "DOSE Alarm" is the dose alarm value for an External GMT in R (i.e., a GMT probe affixed to a worker's arm, leg or head and plugged into one of the PDE-4's™ four external probe connectors).
- Q) "RATE Alarm" is the dose rate alarm value for an External GMT in R/h.
- R) "CHIRP Incrmnt" is the dose increment between audible chirps for an External GMT in R.
- S) "DOSE Cal" is the linear calibration factor for an External GMT in μR/count. This is the scaling factor used to convert counts detected by the External GMT to dose values in μR (by multiplication). Option 'M' of PDRC4 (LCAL) will compute and install a new value for DOSE Cal based on the application of a known dose increment to the External GMT.

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- T) "GMT Dead Time" is the effective time interval in μs that an External GMT is dead (unable to respond to radiation) following a Geiger avalanche. Measured dose increments and dose rates are corrected by the factor, $1/(1-C\tau)$ where C is the measured GMT counting rate and τ is the GMT Dead Time. Option 'N' of PDRC4 (DCAL) will compute and install a new value for GMT Dead Time based on the application of a known dose increment at a known rate to the External GMT.
- U) "BKGD Corr" is the spontaneous count rate (in units of counts/1024 s) generated by an External GMT. This includes all counts that are not related to the ambient radiation field such as counts generated by decay of radioactive isotopes in the GMT's structural materials. BKGD Corr is used to correct both dose and dose rate values. The dose correction can be significant if the PDE-4™ is operated continuously at background radiation levels.
- V) "Factory Serial No", when shipped from the factory, is the serial number of the External Probe to which the calibration factors apply. The Factory Serial No registers for all four external probes are transmitted as part of the PDE-4's™ data message for record keeping purposes. The actual values contained by these registers have no effect on PDE-4™ operation.
- 7) "Time>RATE Alm" is the total integrated time in minutes since the last PDE-4™ reset operation that an External GMT measured a dose rate in excess of the RATE Alarm value (these items are not subject to editing).
- 8) "Total DOSE" is the total accumulated dose in R measured by an External GMT since the last PDE-4™ reset operation (these items are not subject to editing).
- 9) "Peak RATE" is the maximum dose rate measured by an External GMT since the last PDE-4™ reset operation (these items are not subject to editing).

6.0 PD(E)-4 Calibration

Three EEPROM values affect the calibration of each PD(E)-4 GMT Sensor. These are DOSE Cal, GMT Dead Time and BKGD Corr. During factory calibration, nominal values are written into the appropriate Registers before exposing the unit to a 7.5 minute linear calibration dose of 95 mR at 760 mR/h and a 30 second dead time calibration dose of 3.8 R at 456 R/h [the PD(E)-4 is linearly calibrated and then zeroed between calibration exposures].

PLEASE NOTE:

Linear calibration must precede dead time correction or totally unreasonable values can be obtained. Acceptable factory defaults are 1.4 $\mu\text{R}/\text{count}$ for the linear calibration constant and 20 μs for the dead time correction.

Denoting the nominal values as $DSCF_n$ and $GMDT_n$ and the resulting PD(E)-4 dose readings as $DOSE_{ln}$ and $DOSE_{dt}$, the corrected calibration values are computed as

$$DSCF = DSCF_n \times 0.095 / DOSE_{in} \quad \text{and}$$

$$GMDT = GMDT_n + 30 \times DSCF \times (1.0/DOSE_{dt} - 1.0/3.8) ,$$

where the constant, 30, is the length of the dead time exposure in seconds and the constant, 3.8, is the dead time dose in R. BKGD Corr is established by first pre-setting it to 0, zeroing the PD(E)-4, and then allowing the unit to accumulate background dose overnight (or longer). Denoting the ambient background radiation level as RATE_{bg}, the background exposure time in hours as TIME_{bg}, and the resulting PD(E)-4 DOSE Reading as DOSE_{bg}, the appropriate value for BKGD Corr is calculated as

$$BKGD = 1024 \times (DOSE_{bg}/TIME_{bg} - RATE_{bg}) / (3600 \times DSCF) .$$

The above equations for DSCF and GMDT are implemented in the Linear calibration and Dead-Time correction routines of PDRC4 as Option 'M' (LCAL) and Option 'N' (DCAL). To use these calibration options, simply follow the procedures outlined below (or see Appendix F for a more detailed calibration procedure):

IMPORTANT:

If an abortive calibration has resulted in totally erroneous values being written into the PD(E)-4's EEPROM, they must be replaced with reasonable values before recalibration is attempted. This can easily be accomplished with Main Menu Option "D. WT60H" of PDRC4 which writes default values into the lower 96 registers of the PD(E)-4's EEPROM memory.

Linear Calibration

- a. Insure that the current value of the appropriate linear calibration factor is in the range from 1.0 to 3.0 μ R/count.
- b. Place a PD(E)-4 on the PDR-1™ or PDR-1/S™ Reader and reset the dose.
- c. Expose the PD(E)-4 to a dose in the range from 10 mR to 1.0 R at a rate in the range from 10 mR/h to 3.0 R/h.
- d. Return the PD(E)-4 to the PDR.
- e. Running PDRC4 software, select main menu option 'M'.
- f. Enter the known exposure.
- g. Press Y to read the PD(E)-4.
- h. Confirm the "As-Found", "As-Left", and new linear calibration factor information that is presented.
- i. Enter a Y into the far left column of the rows containing information you wish to send to the PD(E)-4. Place an N in the far left column for the rows you wish to reject.
- j. Press ESC once when finished.
- k. Next Press any key except ESC to transmit the chosen calibration information to the PD(E)-4, or press ESC to ABORT sending information.

Dead-Time Correction

- a. Insure that the current value of the appropriate dead time correction factor is in the range from 10 to 30 μ s/count.
- b. Place a PD(E)-4 on the PDR-1™ or PDR-1/S™ Reader and reset the dose.

- c. Expose the PD(E)-4 to a dose in the range from 100 mR to 10 R at a rate in the range from 100 R/h to 500 R/h.
- d. Return the PD(E)-4 to the PDR.
- e. Running PDRC4 software, select main menu Option 'N'.
- f. Enter the known exposure and exposure rate.
- g. Press Y to read the PD(E)-4.
- h. Confirm the "As-Found", "As-Left", and new dead-time correction information that is presented.
- i. Enter a Y into the far left column of the rows containing information you wish to send to the PD(E)-4. Place an N in the far left column for the rows you wish to reject.
- j. Press ESC once when finished.
- k. Next Press any key except ESC to transmit the chosen dead-time correction information to the PD(E)-4, or press ESC to ABORT sending information.

7.0 PD(E)-4 Accessories

PD-1™ Alarming Dosimeter

A full featured electronic dosimeter packaged in a pager size unit. The PD-1™ offers total dose, dose rate and set point check displays. This unit can operate as a stand-alone dosimeter using pre-set alarms. The PD-1™ operates on any standard AA battery.

Alarming Dosimeter, Sieverts

Alarming pocket size dosimeter that provides dose measurement, dose rate measurement, dose alarm, rate alarm, and chirp. In addition, the PD-2™ offers stay-time alarm, dose and stay-time warning alarms, and dose history. The PD-2™ operates on any standard AA battery.

PD-3™ Alarming Dosimeter, R

Alarming pocket size dosimeter that provides the same features as the PD-2™ in a R displaying device.

PDE-2™ Extremity Monitor, Sieverts

Full function extremity monitoring alarming dosimeter/ratemeter with external sensor. The PDE-2™ offers total dose, dose rate, chirper, set-point check, and alarms, all in a convenient pager size unit.

PDE-3™ Extremity Monitor, R

Extremity monitoring alarming dosimeter that provides the same features as the PDE-2™ in a R displaying device.

PD-10™ Alarming Dosimeter, R

Enhanced version of PD-3™ dosimeter allowing stand-alone operation. The alarm levels and most options can be changed without the need for a PDR-1 Reader.

PD-12™ Alarming Dosimeter, Sieverts

Sieverts displaying version of the PD-1™.

PDE-10™ Extremity Monitor, R

Enhanced version of the PDE-3™ extremity monitor allowing stand-alone operation. The alarm levels and most options can be changed without the need for a PDR-1™ Reader.

PDE-12™ Extremity Monitor, Sieverts

Sieverts displaying version of the PDE-10™.

PDR-1™ Personal Dosimeter Reader

The PDR-1™ Personal Dosimeter Reader provides the interface between the PD Series of Personal Dosimeters and computer via an RS-232 connection. The PDR-1™ also includes a Manual Dose Reset button.

PDR-1/S™ Personal Dosimeter Reader with Check Source

The PDR-1/S™ Personal Dosimeter Reader with Check Source is identical to the PDR-1™ with the addition of an internal check source. The radioactive check source is microprocessor controlled. When using the check source, the PD Series Personal Dosimeter is exposed to sufficient dose to provide confirmation of operability immediately before the user enters a work area.

RadStar Radio Transmission Dosimetry

The RadStar System provides the latest in Radio Transmission Dosimetry. With its two-way communication, RadStar provides the most robust and reliable real-time monitoring capability available today. The system is composed of the PD-4™ Dosimeter, the PDE-4™ Extremity Monitor with up to four extremities and whole body monitored simultaneously, the PDX-4™ RadBase, and a base PC computer.

PD-4™

The PD-4™ transmitting and receiving alarming dosimeter sends dose information and receives set points and remote alarms from a central observation location through a robust communications link.

PDE-4™

Like the PD-4™, PDE-4™ transceiving extremity monitor sends dose information and receives set points and remote alarms for whole body. However, the PDE-4™ can add up to four extremity sensors to monitor head, arms, fingers, feet, or other points. Compensated and uncompensated GM tubes are available for sensors.

PDX-4™

PDX-4™ receives and transmits data from multiple PD-4™ dosimeters and PDE-4™ extremity monitors. With its two-way communications capability, alarms can be reset to provide real-time ALARA control. The PDX-4™ provides real-time information for display and processing by a personal computer.

Headsets for Alarming Dosimeter/Extremity Monitor

Two Headsets provide a means of hearing alarms from any PD Personal Dosimeters under medium and high-noise conditions. A rugged, flexible boot placed over the dosimeter provides attachment for an acoustically coupled headset.

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For medium noise environments, the 201023 Earphone uses an earpiece which allows for near normal hearing to occur. For high-noise environments, the 201043 Earphone provides sound protection in addition to the acoustic coupling to the dosimeter.

Underwater Antenna

The SAIC part number 201550 underwater antenna is a rugged, flexible communication link designed for underwater monitoring applications. The SAIC part number 201550 assembly has a standard length of 100 feet and connects directly to the SAIC model PDX-4™ to provide two way communication with SAIC Model PD-4™ dosimeter and PDE-4™ extremity monitors.

RadStar™ Carry Pouch

The SAIC model number 4100-72 carry pouch is a rugged, lightweight pouch with straps used to secure the SAIC model PD-4™ dosimeter or PDE-4™ extremity monitor to a workers body.

Alarm Amplifier

The AA-4 Alarm Amplifier provides a means of hearing alarms from any PD series dosimeter under high noise conditions. The AA-4 is worn at the waist and connects to the dosimeter via flexible boot and a short length of tubing. The sound output is a minimum 110 dBA @ 20 cm continuous tone.

PDS-3™ Elementary Dose Tracking Software for the PC

PDS-3™ Elementary Dose Management Software provides a menu driven software package for controlling the features and operation of PD Series Personal Dosimeters. An internal database is included which will record information relative to the PD Series Dosimeters. Basic reports can be selected from a menu. A PDR-1™ or PDR-1/S™, Personal Dosimeter Reader is required for communicating between the PD Series Personal Dosimeters and the PDS-3™ software. PDS-3™ operates under the DOS operating system.

ARACS Automated Access Control System

ARACS is a complete system to your dose management requirements. The flexible systems approach used in the development of the ARACS allows any system to be easily modified to work with existing systems or satisfy unique user requirements.

PRORAD 10CFR20 Compliance System

PRORAD integrates the data collection and processing capability of the Health Physics and Corporate information systems to provide a system in compliance with 10CFR20 requirements.

REMedy

REMedy Internal Dosimetry Evaluation System is designed to reduce the time commitment and improve the quality of the final result for many of the key tasks which confront dosimetry staff. REMedy has more computational, editing, display, and documentation features than any other commercially available internal dosimetry program.

Remit

Developed with the NRC, Remit assists users in meeting their electronic reporting requirements under 10CFR20.

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Services

SAIC offers a variety of Health Physics Services. Only a few samples are listed here. Please call for additional information.

NVLAP and DOELAP Training

SAIC offers on-site training for the National Voluntary Laboratory Accreditation Program (NVLAP) for external dosimetry and DOELAP.

HP Services

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RadStarTM How-To Manual

Sample Network Architectures

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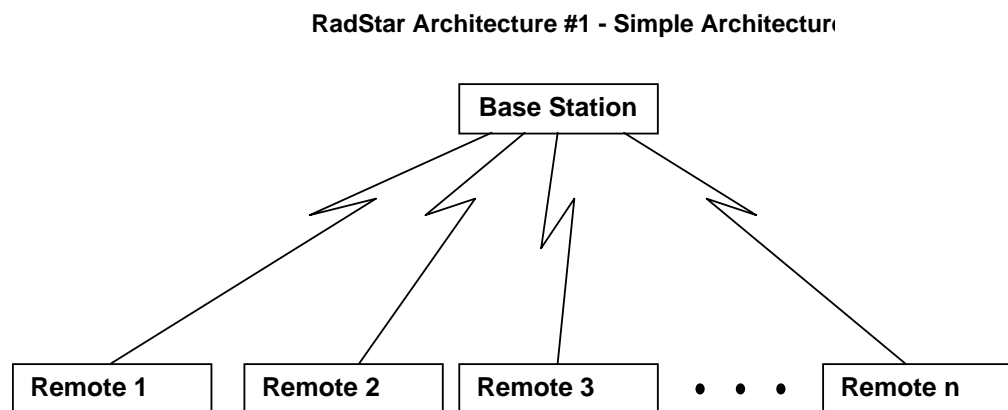
Introduction

Welcome to SAIC's RadStar System. The RadStar is the most reliable and flexible radiation information transmitting system available today. Several system architectures are available to you. Five architectures are presented here which will provide you solutions to your most difficult radio transmission situations. They are easily configured through the PDRC4 and RS software packages.

The architectures presented here are representative of a few of the many possible architectures. Should you have a special situation where you do not see an obvious solution, please call us and we will be happy to assist you.

Architecture #1 - Simple

When the RadStar System was shipped to you, it was configured for use in the Simple Architecture. The figure shows this architecture.



Application

Simple communication requirements not obstructed by significant building structures or requiring long distances.

PD-4/PDE-4 Set-Up as Remote Units

(Note: This set up is required only if the configuration has been modified since the PD-4/PDE-4 units left the factory)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDRC4 application software.
3. Press ENTER until the main menu appears.
4. Place a PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Confirm the "Repeater" is disabled. If it is enabled, use the cursor and TAB key to move to the field. Use the space bar to toggle to disable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not, use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear. Confirm that the Lost-Coms to Re-Acq field value is set to 3. If not use the TAB and cursor keys to move to the field and enter the appropriate setting.
10. Press ESC.
11. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
12. If Lost Comm is enabled, the units will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button of the PD-4/PDE-4.
13. Press ESC or ENTER to return to the main menu.
14. Repeat steps 4 through 10 for all Remote Units.
15. Press Z. to exit PDRC4 and return to DOS.

PDX-4 RadBase Set-Up

(Note: This set up is required only if the configuration has been modified since the PDX-4 and RS Set-Up left the factory)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'E. Base Station Controller Setup'.
5. Confirm that Radio Channel = 4. If not, type 4 and press ENTER.
6. Confirm that Radio Subchannel = 1. If not, type 1 and press ENTER.
7. Confirm that Communication Group # = 00000. If not, type 0 and press ENTER.
8. Confirm MAX Units for this Base-Station is large enough to accommodate all of the units you will be attaching, for example 4. RS currently limits this number to 16. This is a temporary PC software limitation, not a RadStar System limitation.
9. Confirm MAX Direct Remotes for this Base-Station is large enough to accommodate all of the units you will be attaching, for example, 4.
10. MAX Direct Repeaters is not relevant for this architecture and should be set to 0.
11. Press ESC or ENTER to return to the main menu.
12. Confirm Save Message-Log(s) is set to N by pressing N and ENTER.

Remote Monitoring

(Note: Skip steps 1 through 3 if you have just finished PDX-4 RadBase Set-Up)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'A. PDX-4 Base Station Controller'.
5. Turn on the PD-4/PDE-4 Units. They will automatically appear on the screen in the order in which they acquire the Base Station.
6. See the section on Modifying Transmission Interval and Alarm Set Points for information on modifying the PD-4/PDE-4 settings.
7. When finished monitoring, press ESC to exit to main menu.
8. Select 'F. Exit to DOS' to leave RS.

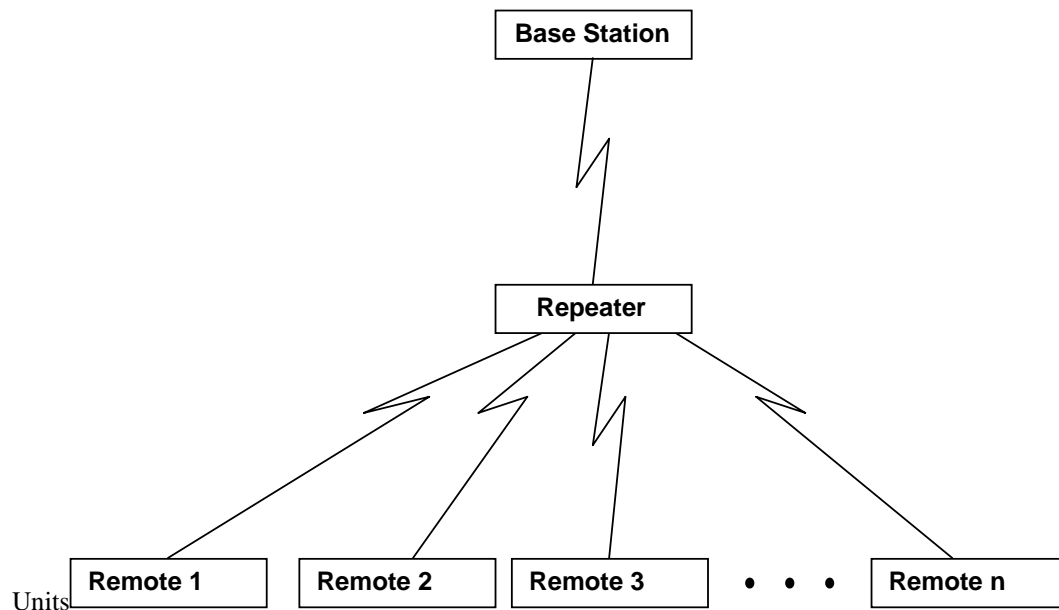
Architecture #2 - One Repeater

Application

Use this architecture for situations where you need additional distance between the Base Station and the Remote units or where obstructions or RF interference prevent reliable communications.

PD-4/PDE-4 Set-Up as Remote

RadStar Architecture #2 - One Repeater



Note: This set up is required only if the configuration has been modified since the PD-4/PDE-4 units left the factory)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDRC4 application software.
3. Press ENTER until the main menu appears.
4. Place a PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Confirm the "Repeater" is disabled. If it is enabled, use the cursor and TAB key to move to the field. Use the space bar to toggle to disable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear. Confirm that the Lost-Coms to Re-Acq field is value to 3. If not use the TAB and cursor keys to move to the field and enter the appropriate setting.
10. Press ESC.
11. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
12. If Lost Comm is enabled, the units will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button the the PD-4/PDE-4.
13. Press ESC or ENTER to return to the main menu.
14. Repeat steps 4 through 10 for all Remote Units.
15. Press Z. to exit PDRC4 and return to DOS.
16. Turn of the PD-4/PDE-4s.

PD-4/PDE-4 Set-Up as Repeater Unit

(Note: Skip steps 1 through 3 if you have just finished PD-4/PDE-4 Set-Up as Remote Units)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.

2. Start the PDRC4 application software.
3. Press ENTER until the main menu appears.
4. Place a PD-4 or PDE-4 on the reader.
5. Select 'edit' by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Set "Repeater" to enabled by using the cursor key to move to the field. Use the space bar to toggle to enable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not, use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear. Confirm that the Lost-Coms to Re-Acq field value is set to 3. If not use the TAB and cursor keys to move to the field and enter 3.
10. Press ESC.
11. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
12. If Lost Comm is enabled, the unit will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button of the PD-4/PDE-4.
13. Press ESC or ENTER to return to the main menu.
14. Press Z. to exit PDRC4 and return to DOS.
15. Turn off the PD-4/PDE-4.

PDX-4 RadBase Set-Up

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'E. Base Station Controller Setup'.
5. Confirm that Radio Channel = 4. If not, type 4 and press ENTER.
6. Confirm that Radio Subchannel = 1. If not, type 1 and press ENTER.
7. Confirm that Communication Group # = 00000. If not, type 0 and press ENTER.
8. Confirm MAX Units for this Base-Station is large enough to accommodate all of the units you will be attaching. For example, if you are attaching 4 Remotes and 1 Repeater, set this value to at least 5. RS currently limits this number to 16. This is a temporary PC software limitation, not a RadStar System limitation.
9. To force the Remote units to transmit through the Repeater, set the MAX Direct Remotes for this Base-Station equal to 0.
10. Set MAX Direct Repeaters to 1.
11. Press ESC or ENTER to return to the main menu.
12. Confirm Save Message-Log(s) is set to N by pressing N and ENTER.

Remote Monitoring

(Note: Skip steps 1. through 3 if you have just finished PDX-4 RadBase Set-Up)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'A. PDX-4 Base Station Controller'.
5. Turn on the Repeater PD-4/PDE-4 Unit. It will automatically appear on the screen. The word REPEATER will first appear in blue, then change to yellow.
6. Turn on the Remote PD-4/PDE-4 Units. They will automatically appear on the screen as they acquire the Repeater and Base Station.
7. See the section on Modifying Transmission Interval and Alarm Set Points for information on modifying the PD-4/PDE-4 settings.
8. When finished monitoring, press ESC to exit to main menu.
9. Select 'F. Exit to DOS' to leave RS.

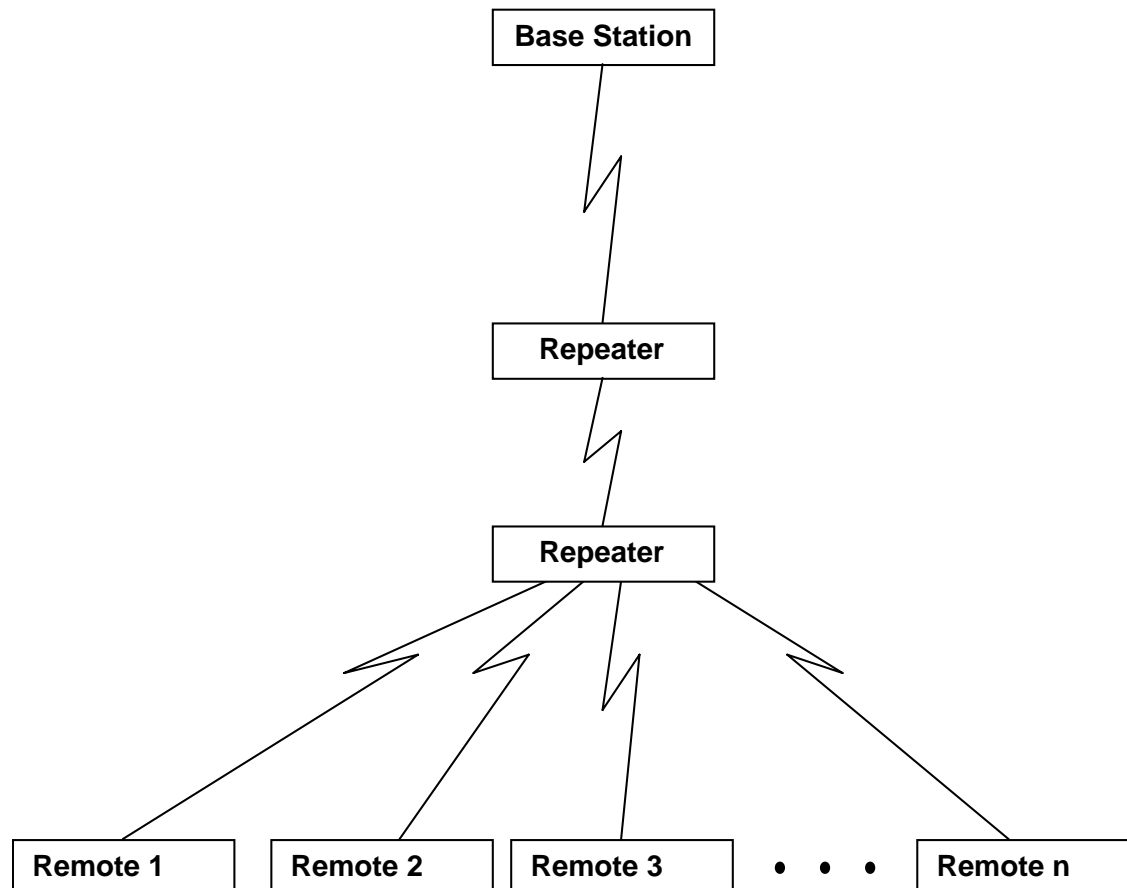
10. Turn off the PD-4/PDE-4 Units.

Architecture #3 - Two Repeaters in Series

Application

Use this architecture for situations where you have significant distances you need to transmit or a very difficult obstruction, such as a containment wall.

RadStar Architecture #3 - Two Repeaters



PD-4/PDE-4 Set-Up as Remote Units

(Note: This set up is required only if the configuration has been modified since the PD-4/PDE-4 units left the factory)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDRC4 application software.
3. Press ENTER until the main menu appears.
4. Place a PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Confirm the "Repeater" is disabled. If it is enabled, use the cursor and TAB key to move to the field. Use the space bar to toggle to disable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear. Confirm that the Lost-Coms to Re-Acq field is value to 3. If not use the TAB and cursor keys to move to the field and enter the appropriate setting.
10. Press ESC.
11. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)

12. If Lost Comm is enabled, the units will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button of the PD-4/PDE-4.
13. Press ESC or ENTER to return to the main menu.
14. Repeat steps 4 through 10 for all Remote Units.
15. Press Z. to exit PDR4 and return to DOS.
16. Turn of the PD-4/PDE-4s.

PD-4/PDE-4 Set-Up as Repeater Units

(Note: Skip steps 1 through 3 if you have just finished PD-4/PDE-4 Set-Up as Remote Units)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDR4 application software.
3. Press ENTER until the main menu appears.
4. Check the Serial Numbers of the PD-4/PDE-4s you intend to use as Repeaters. Place the lower numbered PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Set "Repeater" to enabled by using the cursor key to move to the field. Use the space bar to toggle to enable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not, use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear.
10. Set Attach Lower FSNs (Factory Serial Numbers) to DISABLE by highlighting the field and toggling with the space bar.
11. Confirm that the Lost-Coms to Re-Acq field value is set to 3. If not use the TAB and cursor keys to move to the field and enter 3.
12. Set Max Direct Remotes to 0.
13. Set Max Direct Repetrs to 1.
14. Press ESC.
15. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
16. If Lost Comm is enabled, the unit will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button the the PD-4/PDE-4.
17. Press ESC or ENTER to return to the main menu.
18. Place the second (higher factory serial number) unit on the reader.
19. Repeat steps 5 through 11.
20. Set Max Direct Remotes to a number large enough for all the Remotes you plan to use. For example, if you will be using 4 Remotes, set this number to at least 4. (With the temporary limit of 16 units connected to the Base at one time, the maximum number of units should always be set to 14 or less.)
21. Set Max Direct Repetrs to 0.
22. Press ESC.
23. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
24. If Lost Comm is enabled, the unit will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button the the PD-4/PDE-4.
25. Press ESC or ENTER to return to the main menu.
26. Press Z. to exit PDR4 and return to DOS.
27. Turn off the PD-4/PDE-4s.

PDX-4 RadBase Set-Up

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'E. Base Station Controller Setup'.
5. Confirm that Radio Channel = 4. If not, type 4 and press ENTER.
6. Confirm that Radio Subchannel = 1. If not, type 1 and press ENTER.
7. Confirm that Communication Group # = 00000. If not, type 0 and press ENTER.

8. Confirm MAX Units for this Base-Station is large enough to accommodate all of the units you will be attaching. For example, if you are attaching 4 Remotes and 2 Repeaters, set this value to at least 6. RS currently limits this number to 16. This is a temporary PC software limitation, not a RadStar System limitation.
9. To force the Remote units to transmit through the Repeater, set the MAX Direct Remotes for this Base-Station equal to 0.
10. Set MAX Direct Repeaters to 1.
11. Press ESC or ENTER to return to the main menu.
12. Confirm Save Message-Log(s) is set to N by pressing N and ENTER.

Remote Monitoring

(Note: Skip steps 1. through 3 if you have just finished PDX-4 RadBase Set-Up)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'A. PDX-4 Base Station Controller'.
5. Turn on the Repeater with the lower factory serial number. It will automatically appear on the screen. The word REPEATER will first appear in blue, then change to yellow.
6. Turn on the second Repeater. Again, the word REPEATER will first appear in blue, then change to yellow.
7. Turn on the PD-4/PDE-4 Remote units. They will automatically appear on the screen as they acquire the Repeaters and Base Station.
8. See the section on Modifying Transmission Interval and Alarm Set Points for information on modifying the PD-4/PDE-4 settings.
9. When finished monitoring, press ESC to exit to main menu.
10. Select 'F. Exit to DOS' to leave RS.
11. Turn off the PD-4/PDE-4 Units.

Architecture #4 - Three Repeaters in Series

1. Introduction

A forced architecture is not generally recommended since, with proper settings, the RadStar system will automatically establish its connection. However, under special circumstances such as a long distance connection, it may be desirable to force a particular architecture.

The following procedure establishes an architecture which creates the following linkage:

Base <—> Repeater <—> Repeater <—> Repeater <—> Remote

Any PD-4 or PDE-4 dosimeter can be made to act as a repeater.

2. PD Preparation

- 2.1 Gather the four PD-4 or PDE-4 dosimeters (PDs), the PDR-1 or PDR-1/S (PDR), and a PC together.
- 2.2 Sort the PDs by serial number. The repeaters will be deployed in numerical order starting with the lowest number being placed closest to the base.
- 2.3 Attach the PDR-1 to a PC as described in the PDR-1 manual.
- 2.4 Turn on the PC and the PDR-1.
- 2.5 Start PDRC4 from the DOS prompt.
- 2.6 After the title and configuration screens appear, press ESC or ENTER to access the Main Menu.
- 2.7 Turn on the lowest serial number PD and place it on the PDR.
- 2.8 Configuring the First Repeater:

- 2.8.1 Press A to activate the 'A. Edit' menu option.
- 2.8.2 Enable the repeater mode by using the up and down cursor to move to the option indicated in Figure 1. Use the space bar to toggle the Repeater Mode option to ENABLED.
- 2.8.3 Confirm that the Control Group, Broadcast Address, Radio Channel, and Radio Sub-channel are as shown in Figure 1 (or alternatively, that all of the instruments used for this job have identically matching settings).

Note: A PD which is actively in repeater mode, indicated by rPr on the display, will not communicate with a PDR-1 reader for normal read-write functions using PDRC4. The unit must be turned off and then turned back on to cancel the repeater mode before normal reading can resume.

- 2.8.4 Press ESC to access the next setup screen.

PD-4 EEPROM EDITING UTILITY

ZERO Date:	23-Mar-94	BKGD Cor1 (c/1024s):	0
ZERO Time:	19:09:08	DOSE Cal2 (R/cnt):	1.50 μ
User ID String:	' RTE4 '	GMT Dead Time2 (s)	20.0 μ
(or numeric) :	3731143636	BKGD Cor2 (c/1024s):	0
Contrl Group:	CG00000	Time>RATE Alr1 (m):	0.00
Broadcast Address:	FFFFFFF ←	Time>RATE Alr2 (m):	0.00
Radio Channel:	4	Total DOSE1 (R):	2.80 μ
Radio Sub-channel:	1	Total DOSE2 (R):	0.00
Transmit Int (s):	10.0	Peak RATE1 (R/h):	84.3 μ
Xmit on Lo-Bat (m):	5.00	Peak RATE2 (R/h):	0.00
GMT Alarm (1024 s):	2	Factory Serial No:	RT01029
DOSE Alarm1 (R):	1.00	Options:	
RATE Alarm1 (R/h):	10.0	Audio RATE Alarm	ENABLED
CHIRP Inc1 (R):	10.0 m	RATE Mode	ENABLED
DOSE Alarm2 (R):	1.00	Repeater Mode	ENABLED ←
RATE Alarm2 (R/h):	10.0	Audio DOSE Alarm	ENABLED
CHIRP Inc2 (R):	10.0 m	Audio CHIRP	ENABLED
CAL Date:	00-NUL-00	LOST Comm Alarm	DISABLED
CAL Time:	0:00:00	Transmission Mode	PNTtoPNT
DOSE Cal1 (R/cnt):	1.40 μ	Audio during Comm	DISABLED
GMT Dead Time1 (2):	21.4 μ	Audio during Lo-Bat	DISABLED

Figure 1

- 2.8.5 Make the data match the information presented in Figure 2.

Note: The attachment of lower Factory Serial Numbers (FSNs) should be disabled so that the repeaters will attach in series. By limiting the number of attachments to 1 and limiting the maximum number of remotes to 0 and the number of repeaters to 1, only one repeater can attach to this repeater. No other devices will attach.

Note: "Max Attachments" is the maximum number of devices, including repeaters and remotes, that can eventually communicate through this repeater.

- 2.8.6 Press ESC once.
- 2.8.7 Press **any key except ESC** to initiate writing the changes to the dosimeter.
- 2.8.8 If any error messages appear, press ESC, make sure the PD is appropriately set on the PDR, and repeat steps 2.8.1 through 2.8.7.

- 2.8.9 Press ESC to return to the main menu.
- 2.8.10 Remove the PD from the PDR and turn it off. Failure to turn off this unit now may make it impossible to proceed with the next step.

PD-4 REPEATER EEPROM EDITING UTILITY

Lost-Coms to Re-Acq:	3		Options:	
Max attachments:	3	←	Auto-'A' Command	ENABLED
Max Direct Remotes:	0	←	Attach Lower FSNs	DISABLED ←
Max Direct Repeaters:	1	←		

Figure 2

2.9 Configuring the Second Repeater

2.9.1 Turn on the next PD and place it on the PDR.

2.9.2 Repeat each of the steps found in 2.8 **except use Figure 3** instead of Figure 2 in step 2.8.5. The difference between the two figures is indicated. Don't forget to turn off this unit when its configuration is complete.

PD-4 REPEATER EEPROM EDITING UTILITY

Lost-Coms to Re-Acq:	3	Options:	
Max attachments:	2 ←	Auto-'A' Command	ENABLED
Max Direct Remotes:	0	Attach Lower FSNs	DISABLED
Max Direct Repeaters:	1		

Figure 3

2.10 Configuring the Third Repeater

2.10.1 Turn on the next PD which is the final repeater and place it on the PDR.

2.10.2 Repeat each of the steps found in 2.8 **except use Figure 4** instead of Figure 2 in step 2.8.5. By allowing the attachments of lower Factory Serial Number units (as well as higher numbered units which are always allowed to attach), limiting the attachments to 1 unit, limiting the number of remotes to 1, and not allowing any repeaters to attach, the remote PD will be forced to transmit through this repeater regardless of its factory serial number.

PD-4 REPEATER EEPROM EDITING UTILITY

Lost-Coms to Re-Acq:	3		Options:	
Max attachments:	1	←	Auto-'A' Command	ENABLED
Max Direct Remotes:	1	←	Attach Lower FSNs	ENABLED ←
Max Direct Repeaters:	0	←		

Figure 4

2.11 Configuring the Remote

- 2.11.1 Turn on the PD which is to be used as the remote, radiation measuring dosimeter, and place it on the PDR.
- 2.11.2 Press A to activate the 'A. Edit' menu option.
- 2.11.3 Confirm that the Control Group, Broadcast Address, Radio Channel, and Radio Sub-channel are as shown in Figure 5 (or alternatively, that all of the instruments used for this job have identically matching settings).
- 2.11.4 Press ESC to access the next setup screen.

PD-4 EEPROM EDITING UTILITY

ZERO Date:	23-Mar-94	BKGD Cor1 (c/1024s):	0
ZERO Time:	19:04:20	DOSE Cal2 (R/cnt):	1.35 μ
User ID String:	' RTE4 '	GMT Dead Time2 (s)	15.7 μ
(or numeric) :	3731143636	BKGD Cor2 (c/1024s):	0
Contrl Group:	CG00000	Time>RATE Alr1 (m):	0.00
Broadcast Address:	FFFFFFF	Time>RATE Alr2 (m):	0.00
Radio Channel:	4	Total DOSE1 (R):	107 μ
Radio Sub-channel:	1	Total DOSE2 (R):	0.00
Transmit Int (s):	5.00	Peak RATE1 (R/h):	19.3 m
Xmit on Lo-Bat (m):	5.00	Peak RATE2 (R/h):	0.00
GMT Alarm (1024 s):	2	Factory Serial No:	RE01091
DOSE Alarm1 (R):	501 m	Options:	
RATE Alarm1 (R/h):	10.0	Audio RATE Alarm	ENABLED
CHIRP Inc1 (R):	10.0 m	RATE Mode	ENABLED
DOSE Alarm2 (R):	1.00	Repeater Mode	DISABLED
RATE Alarm2 (R/h):	10.0	Audio DOSE Alarm	ENABLED
CHIRP Inc2 (R):	10.0 m	Audio CHIRP	ENABLED
CAL Date:	00-NUL-00	LOST Comm Alarm	DISABLED
CAL Time:	0:00:00	Transmission Mode	PNTtoPNT
DOSE Cal1 (R/cnt):	1.34 μ	Audio during Comm	DISABLED
GMT Dead Time1 (2):	20.0 μ	Audio during Lo-Bat	DISABLED

Figure 5

- 2.11.5 Make the data match the information presented in Figure 6. Note that the only value in this figure that is relevant to remote operation is Lost-Coms to Re-Acq.
- 2.11.6 Press ESC once.
- 2.11.7 Press **any key except ESC** to initiate writing the changes to the dosimeter.
- 2.11.8 If any error messages appear, press ESC, make sure the PD is appropriately set on the PDR, and repeat steps 2.11.1 through 2.11.7.
- 2.11.9 Press ESC to return to the main menu.
- 2.11.10 Turn off the PD and remove it from the PDR.
- 2.12 Press Z to select Z. Exit

PD-4 REPEATER EEPROM EDITING UTILITY

Lost-Coms to Re-Acq:	3 ←	Options:	
Max attachments:	10	Auto-'A' Command	ENABLED
Max Direct Remotes:	10	Attach Lower FSNs	ENABLED
Max Direct Repeaters:	0		

Figure 6

2.13 Turn off the PDR and disconnect it from the PC.

3. Base Station Preparation

- 3.1 Connect the PDX-4 to the PC and provide it power.
- 3.2 Start RS from the DOS prompt. The PDX-4 will measure RF activity and present the information on the screen.
- 3.3 Press ENTER or ESC to access the main menu.
- 3.4 Select option "E. Base Station Controller Setup" by pressing E or move the highlighted bar with the up and down arrows.
- 3.5 Respond to each of the questions in order, making the changes indicated in Figure 7. Confirm that the Control Group, Broadcast Address, Radio Channel, and Radio Sub-channel are as shown in Figure 7 (or alternatively, that all of the instruments used for this job have identically matching settings). Note that pressing ENTER leaves the previous entry unchanged.
- 3.6 Note: RS will "remember" your settings, so be sure to set them back as appropriate for whatever architecture you generally use after using the system in this mode.
- 3.7 Press ESC or ENTER to access the main menu.

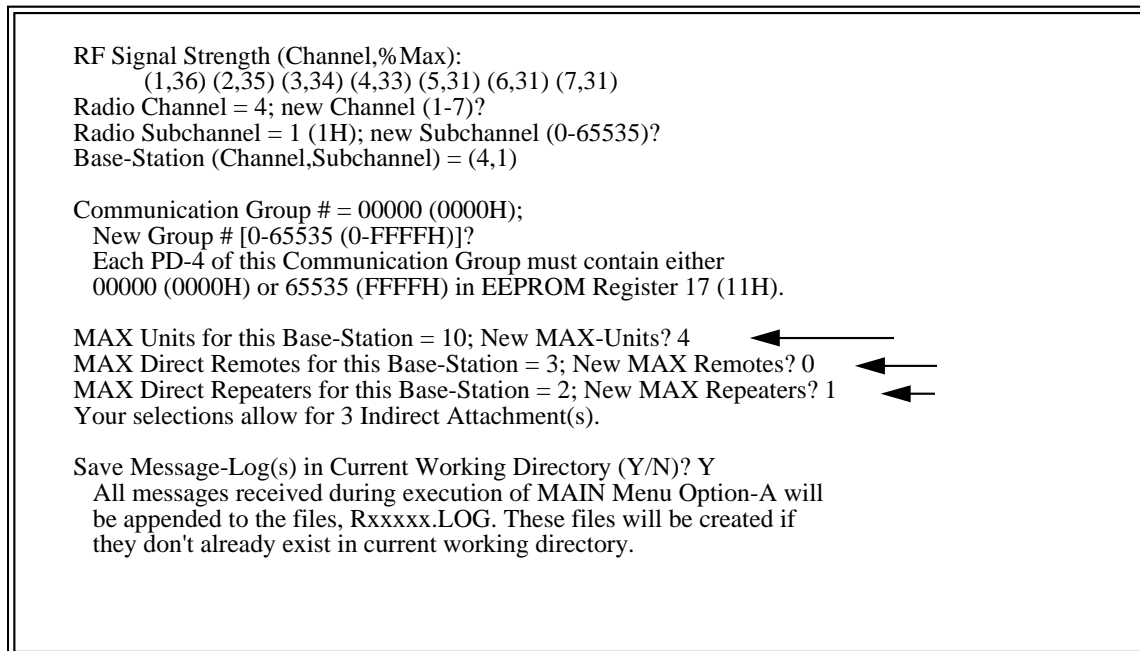


Figure 7

4. Deploying the system

- 4.1 Select Menu Option “A. PDX-4 Base Station Controller” by pressing A or highlighting the option and pressing ENTER.
- 4.2 Repeaters should be deployed with the use of auxiliary power (power transformer or battery packs) as the transceiver is continuously active for a repeater and it draws significant power. Repeaters should also be located at distances and in positions known to allow for reliable communications.
- 4.3 Turn on the first repeater, i.e., the repeater with the lowest serial number. Allow time for the repeater’s serial number and the word REPEATER to appear on the screen. After a moment, it should change color (to yellow on a color screen) and the display of the PD should show “rPr”.
- 4.4 Turn on the second repeater. A similar response should occur with the addition of the repeater’s serial number also appearing on the line containing the first repeater.
- 4.5 Turn on the third repeater. A similar response should occur with the addition of the repeater’s serial number also appearing on the line containing the first repeater.
- 4.6 Finally, turn on the remote unit. The remote device’s normal monitoring information should appear.

5. Shutdown

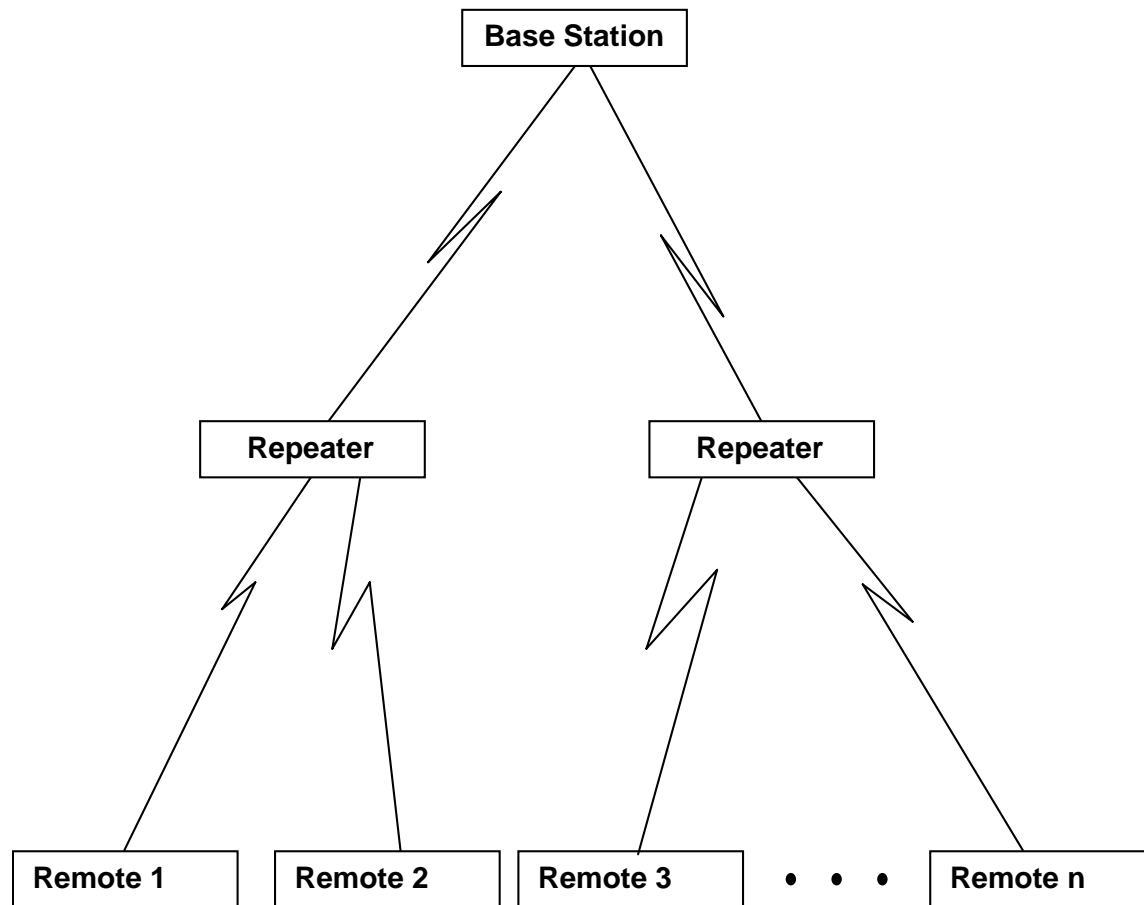
- 5.1 Press ESC to leave the monitoring screen of RS.
- 5.2 You may wish to restore the Base Station Controller Setup at this time to more general settings, e.g., set the maximum number of units for this base station back to 10, maximum direct remotes to 5, maximum number of repeaters to 2, etc.
- 5.3 Select Option F to exit the program
- 5.4 Turn off all devices.
- 5.5 You may wish to restore the settings of the PDs to more general settings for future use at this time, e.g., disable all repeaters, increase the maximum connections, enable attachment of lower FSNs, etc.

Architecture #5 - Roam

Application

Use this architecture for situations where a worker may be roaming over a large area with specific work locations that are far apart or separated by significant physical obstacles. This architecture allows a worker to move out of range of one Repeater while heading towards the other Repeater and reacquire the other Repeater automatically. The operation is nearly transparent to the Base Station operator.

RadStar Architecture #5 - Roam



PD-4/PDE-4 Set-Up as Remote Units

(Note: This set up is required only if the configuration has been modified since the PD-4/PDE-4 units left the factory)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDR4 application software.
3. Press ENTER until the main menu appears.
4. Place a PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting 'A. Edit' and pressing ENTER.
6. Confirm that "Repeater" is disabled. If it is enabled, use the cursor and TAB key to move to the field. Use the space bar to toggle to disable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear. Confirm that the Lost-Coms to Re-Acq field value is set to 3. If not use the TAB and cursor keys to move to the field and enter the appropriate setting.
10. Press ESC.

11. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
12. If Lost Comm is enabled, the units will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button the the PD-4/PDE-4.
13. Press ESC or ENTER to return to the main menu.
14. Repeat steps 4 through 10 for all Remote Units.
15. Press Z. to exit PDRC4 and return to DOS.
16. Turn of the PD-4/PDE-4s.

PD-4/PDE-4 Set-Up as Repeater Units

(Note: Skip steps 1 through 3 if you have just finished PD-4/PDE-4 Set-Up as Remote Units)

1. Attach the PDR Reader to the serial port (COM1 or COM2) of your computer.
2. Start the PDRC4 application software.
3. Press ENTER until the main menu appears.
4. Check the Serial Numbers of the PD-4/PDE-4s you intend to use as Repeaters. Place the lower numbered PD-4 or PDE-4 on the reader.
5. Select edit by pressing 'A' or highlighting A. Edit and pressing ENTER.
6. Set "Repeater" to enabled by using the cursor key to move to the field. Use the space bar to toggle to enable.
7. Confirm that Channel 4 and Subchannel 1 are selected. If not, use the TAB and cursor keys to move to the Channel or subchannel fields and enter the appropriate setting.
8. Press ESC once to confirm you are finished editing.
9. The PD-4 Repeater EEPROM Editing Utility will appear.
10. Set Attach Lower FSNs (Factory Serial Numbers) to DISABLE by highlighting the field and toggling with the space bar.
11. Confirm that the Lost-Coms to Re-Acq field value is set to 3. If not use the TAB and cursor keys to move to the field and enter 3.
12. Set Max Direct Remotes to a number large enough for all the Remotes you plan to use. For example, if you will be using 4 Remotes, set this number to at least 4.
13. Set Max Direct Repetrs to 0.
14. Press ESC.
15. Press any key to download the set points to the PD-4/PDE-4. (To abort the download, press ESC)
16. If Lost Comm is enabled, the unit will alarm. Acknowledge the Lost Comm alarm by pressing the CALL button the the PD-4/PDE-4.
17. Press ESC or ENTER to return to the main menu.
18. Place the second (higher factory serial number) unit on the reader.
19. Repeat steps 5 through 18.
20. Press Z. to exit PDRC4 and return to DOS.
21. Turn off the PD-4/PDE-4s.

PDX-4 RadBase Set-Up

(Note: This set up is required only if the configuration has been modified since the PDX-4 and RS Set-Up has left the factory)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option E. Base Station Controller Setup.
5. Confirm that Radio Channel = 4. If not, type 4 and press ENTER.
6. Confirm that Radio Subchannel = 1. If not, type 1 and press ENTER.
7. Confirm that Communication Group # = 00000. If not, type 0 and press ENTER.
8. Confirm MAX Units for this Base-Station is large enough to accommodate all of the units you will be attaching. For example, if you are attaching 4 Remotes and 2 Repeaters, set this value to at least 6. RS currently limits this number to 16. This is a temporary PC software limitation, not a RadStar System limitation.
9. To force the Remote units to transmit through the Repeater, set the MAX Direct Remotes for this Base-Station equal to 0.
10. Set MAX Direct Repeaters to 2.
11. Confirm Enable automatic time sequencing is set to N by pressing N and ENTER.

12. Press ESC or ENTER to return to the main menu.

Remote Monitoring

(Note: Skip steps 1 through 3 if you have just finished PDX-4 RadBase Set-Up)

1. Attach the PDX-4 RadBase to the serial port (COM1 or COM2) of your computer.
2. Start the RS application software. (As RS starts up, it measures the RF Signal Strength. If you notice a particularly high amount of noise on the channel you wish to use, you may wish to consider selecting a quieter channel as shown by a lower %Max number next to the channel number. If you select a different channel, you will need to repeat PD-4/PDE-4 set-up to set the different channel in the Remote units.)
3. Press ENTER until the main menu appears.
4. Select option 'A. PDX-4 Base Station Controller'.
5. Deploy the Repeaters. Then turn on the Repeaters. They will automatically appear on the screen. The word REPEATER will first appear in blue, then change to yellow.
7. Deploy the PD-4/PDE-4 units. Then turn on the Remote units. They will automatically appear on the screen as they acquire the Repeaters and Base Station.
8. See the section on Modifying Transmission Interval and Alarm Set Points for information on modifying the PD-4/PDE-4 settings.
9. When finished monitoring, press ESC to exit to main menu.
10. Select 'F. Exit to DOS' to leave RS.
11. Turn off the PD-4/PDE-4 Units.

Modifying Transmission Interval and Alarm Set Points with RS.EXE

All PD(E)-4 settings can be modified using PDRC4 software. In addition, key set points can be modified during normal monitoring operations with the RS software package. Set points which can be modified during monitoring operations include dose alarm, rate alarm, chirp dose increment, and the transmission interval. Also, the 'C' all command can be sent to any attached unit.

General

Option 'A' of RS provides for simultaneous control and monitoring of up to 16 PD-4s, 10 PDE-4s, or any combination of 16 units that doesn't exceed the previous two limits. After clearing all buffers of old data, the routine begins looking for PDE-4 activity and inventories the first 16 PD(E)-4 units which report to the Base Station with a DATA Message. Four DATA Items [the PD(E)-4 Factory Serial Number, the PD(E)-4 BATTERY condition, and the Dose and Rate Display values for Internal GMT1] are extracted from this first message and printed to the text screen buffer. In the case of a PDE-4, up to eight additional DATA Items are printed on the next four lines (Dose and Rate Display values for up to four Extremity Monitors). The Base Station immediately commands the source PD(E)-4 to transmit its calibration factors and set points (dose alarm, rate alarm, chirp increment, and transmission interval.) Upon reception, all set point values are also printed to the text screen buffer. DATA Items are updated each time a new DATA Message is received (once per transmission interval for each attached unit).

Cursor and Text Positioning

Methods for interacting with each PD(E)-4 for the Control Group are described below. In general, the target PD(E)-4 is selected by scrolling the text window until the target unit's serial number is visible and then pointing the text cursor at the desired PD(E)-4 Serial Number, or in the case of a PDE-4, at the Serial Number of one of the Extremity Monitors. The following keys are active:

UP_Arrow	Moves cursor up 1 line (may also scroll the window)
DOWN_Arrow	Moves cursor down 1 line (may also scroll the window)
LEFT_Arrow	Moves cursor to top of text window
RIGHT_Arrow	Moves cursor to bottom of text window
PgUp	Scrolls text window up 10 lines (1 page)
PgDn	Scrolls text window down 10 lines (1 page)
Home	Positions first page in text window
End	Positions last page in text window

The Label Command

Upon selecting the Main Menu 'A'-Option, the first display column heading is "Serial Numbers" and the entries in this column are the Factory Serial Numbers of the PD-4 or the PDE-4 and its external sensors. Pressing the F2 key causes the first display column to toggle to "Labels". Initially, these entries will be blank but they can be filled in with up to six ASCII characters by using the Label command. The target PD(E)-4 is selected by positioning the left-hand cursor on its display row using the keys described above. Upon pressing the 'L' key, a prompt appears in the text window to which the operator should respond by providing the desired text string. For instance,

No key press yet	<input type="text" value="___"/>
'L' -key	<input type="text" value="Label/Initials? ___"/>
'R', '-', 'H', 'A', 'N', 'D'-keys	<input type="text" value="Label/Initials? R-HAND___"/>
'Enter'-key	<input type="text" value="___"/>

Upon pressing the 'Enter'-key, the label will appear in the appropriate display row and column. Pressing F2 again will return the display to Serial Numbers. The list of labels is maintained until the program is terminated by returning to DOS.

The Attention/Call Command

In addition to passive monitoring of DATA Messages from up to 16 PD(E)-4s, this routine also allows the operator to interact with each PD(E)-4 unit individually by transmitting one of five possible commands to it. One of the commands requires no argument: the (A)ttention/Call command. This command can be sent simply by pressing the 'A' key followed by the 'Enter' or 'Return' key. Transmission of the 'A' command causes the target PD(E)-4 to begin annunciating the ATTENTION/CALL alarm (1 chirp per second) and the word, "CALL", appears on the target unit's first display row in solid text. When the target PD(E)-4 acknowledges, the Base Station PC rings its bell and "CALL" is extinguished. If a PD(E)-4 initiates the ATTENTION/CALL, "CALL" flashes in the appropriate display row and the Base Station PC rings its bell continuously at 1 Hz until the operator acknowledges by executing the 'A' command (no radio transmission results in this case). Since the 'A' command is not specific to a particular sensor, it can be sent to a PDE-4 by pointing the cursor at the PDE-4 Serial Number or at any one of its associated external sensors. Note that this RadStar 'A' command (ATTENTION) is distinct from the PD(E)-4 'A' command (send Alarms).

Set Point Change Commands

The other four commands allow the Base Station Operator to alter set points in the target PD(E)-4 and require additional numerical input. These commands allow the operator to alter the following: (D)ose Alarm Level, (R)ate Alarm Level, (C)hirp Increment, and (X)mitInt. Upon pressing the 'D', 'R', 'C' or 'X' key, a prompt appears in the text window to which the operator must respond by providing an appropriate value. For instance,

No key press yet	<input type="text" value="___"/>
'D' -key	<input type="text" value="Dose Alarm (R)? ___"/>
'1', '0', '0', 'm', -keys	<input type="text" value="Dose Alarm (R)? 100m___"/>
'Enter'-key	<input type="text" value="___"/>

In the above example, the operator pressed the 'D'-key in order to change the Dose Alarm Level of a particular PD(E)-4. The program responded by prompting with "Dose Alarm (R)? _" which reminds the operator that the new alarm level must be entered in R-units. Then the operator typed "100m", indicating that the desired new set point was 100 mR = 0.100 R. After six keystrokes, the sixth character is overwritten by successive keystrokes. Characters recognized by the data entry routine include only "0123456789.m", and the BACK SPACE or RUBOUT key (not the left cursor arrow key) may be used to eliminate erroneous keystrokes. When the 'Enter' or 'Return' key is pressed, the command and its argument are loaded into a command buffer associated with the target PD(E)-4. Up to five commands (with arguments) can be queued for transmission as soon as the target PD(E)-4's transceiver wakes up. Each PD(E)-4 in the inventory has a separate command buffer. Other keystrokes resulting in a Dose Alarm value of 100 mR include the following:

Dose Alarm (R)? 100.0m__

Dose Alarm (R)? .1__

Dose Alarm (R)? 0.10__

Below are some sample text-windows for changing set points with the R, C and X-commands:

'R'-command Rate Alarm (R/h)? 1.0__

'C' -command Chirp Inc (R)? 0.01m__

'X'-command Xmit Interval (s)? 10__

As in the case of the 'A' command with a PDE-4, the 'X' command can be sent to a PDE-4 by pointing the cursor at the PDE-4 Serial Number or at any one of its associated external sensors.

Any command may be aborted before pressing the 'Enter' or 'Return' key by pressing the F1 key (including the 'A' command). Pressing the 'P' key prints the sequence of letter commands that are currently queued for transmission to the selected PD(E)-4. Command transmission occurs each transmission interval on completion of data message reception.

Diagnostic messages may sometimes appear in the text window. For example, "Command buffer is full!" means that five commands are pending for the selected PD(E)-4 and the operator must wait for these to be transmitted before entering additional commands to the same PD(E)-4. Diagnostic messages can be cleared from the text window by pressing the 'Enter' or 'Return' key.

Diagnostics

The appearance of a question mark (?) in the far right hand side of the text window indicates that some uninterpretable characters were received from the Base Station; in these cases, input characters are discarded, one at a time, until the next valid message header is found (this condition should occur only occasionally when the monitoring routine is initiated). The appearance of an asterisk (*) at the same position means that more than 0.5 s elapsed between the beginning and end of an incoming message. This may occur if the Base Station loses power or if the RS-232 connection is broken. Either character can be cleared by pressing the 'Enter' or 'Return' key. In addition, a question mark or asterisk may appear at the far right of a unit's display row. The question mark means that a clear transmission was still not received after the last retry and the asterisk means that the target unit is either out of range or powered down. These diagnostic symbols can be cleared from the target unit's display row by

pressing the 'Enter' or 'Return' key. Yellow text entries mean that the next expected transmission is at least one second late.

Glossary and Vocabulary

Acquire	Remote devices “acquire” repeaters or base stations as appropriate. The acquired Base Station or Remote becomes the primary target for the Remote's data messages.
Architecture	A connection of Base Station, Repeaters, and Remotes.
Attach	Base Stations “attach” to Repeaters or Remotes as appropriate. Repeaters “attach” to other Repeaters or Remotes as appropriate.
Base Station	A PDX-4 RadBase and a Computer.
Channel	One of seven possible radio channels. Any channel may be used. All units to be operated as a network must use the same channel. Channels 1, 4, and 7 are non-overlapping. We recommend use of Channel 4 in the absence of reasons to select another channel (such as other spread spectrum systems competing for Channel 4).
Remote	Any PD-4 or PDE-4 which is reporting radiation readings. The Remotes are the devices at the end of any communication chain.
Repeater	Any PD-4 or PDE-4 which has been configured to act as a Repeater.
Transmission Interval	Approximate period of time between successive radio transmissions from a remote device. The transmission interval can be increased to reduce the frequency of transmission collisions.