MOD-SIX
Nixie Clock System
Updating Instructions

August 2015

This manual provides instructions for updating the firmware of the MOD-SIX Nixie Clock System firmware as well as a brief firmware revision summary.

Revision/Update Information:	This is a revised manual
Clock Firmware:	V08-08
GPS Repeater-Next Firmware:	V36
Keyfob Firmware:	V14

http://www.badnixie.com

Preface

This manual provides instructions for performing firmware updates as well as a brief firmware version summary for the MOD-SIX Nixie Clock System.

Intended Audience

This manual is intended for all MOD-SIX Nixie Clock System owners.

Important Cautions

Hazardous voltages are present at some locations on the circuit boards when the clock is operating. Avoid touching any components other than the updating dongle while power is applied.

Never install or remove the updating dongle or the RF-Link mezzanine board while power is applied.

Like all electronic devices, the clock system components can be damaged by static electricity. When updating the firmware, always touch the aluminum base plate first to discharge any static.

The tubes are extremely fragile and expensive. Take care to avoid damaging them when removing and reinstalling the acrylic cover and when updating the clock firmware.

1 Identifying the installed firmware

In order to determine if there is a newer version of firmware available for any of your clock components, you will need to first determine the current versions. This chapter provides instructions for identifying the firmware version of each clock system component.

1.1 Identifying clock firmware

Unplug the power cable from the left rear of the clock. Wait a moment and then plug it back in. As part of the clock's startup messages, it will display the firmware version as "Vxx-xx" where xx-xx is the current firmware version.

1.2 Identifying GPS repeater firmware

Disconnect the power from the GPS repeater, either by unplugging the AC adapter from the wall outlet or by unplugging the other end of the power cord from the GPS repeater, whichever will give you a better view of the clock. Wait a few moments and reconnect the GPS repeater's power. The clock display will show a series of messages, one of which will be "NEX xx" where xx indicates the GPS repeater's current firmware version.

Note: **The clock must be running firmware V08-01 or newer *AND* the GPS repeater must be a next-generation model (V31 or newer) in order to display this information. Failure to display messages from the repeater does not identify which of the clock, GPS repeater, or both is out of date.**

Note: **The repeater firmware also displays the version on the repeater's IND LED at power-on. For example, three red blinks followed by six green blinks would indicate firmware V36.**

1.3 Identifying keyfob firmware

Press and hold both the up and down buttons on the keyfob simultaneously until the clock reports the keyfob version. This will happen within 10 seconds. The clock will display a message of the form "F# x-x" where # indicates the keyfob's current address (0-7) and x-x indicates the keyfob's firmware version.

Note: **The clock must be running firmware V08-01 or newer in order to perform this function.**

Note: **The same up + down procedure will also display the keyfob version number on the keyfob LED. For example, one red blink followed by four green blinks would indicate version V14.**

2 Firmware updating procedures

2.1 Clock updating procedure

Clock firmware updates are performed with a small updating dongle. The dongle installs the new firmware onto the clock CPU and is removed once the update is completed.

Note: **Depending on your current clock firmware version, you may or may not receive a clock updating dongle.**

Note: **The dongle checks to make sure it contains appropriate firmware for the device being updated and will not install the update if it is for the wrong device.**

Figure 2–1   Updating Dongle (front and back views)
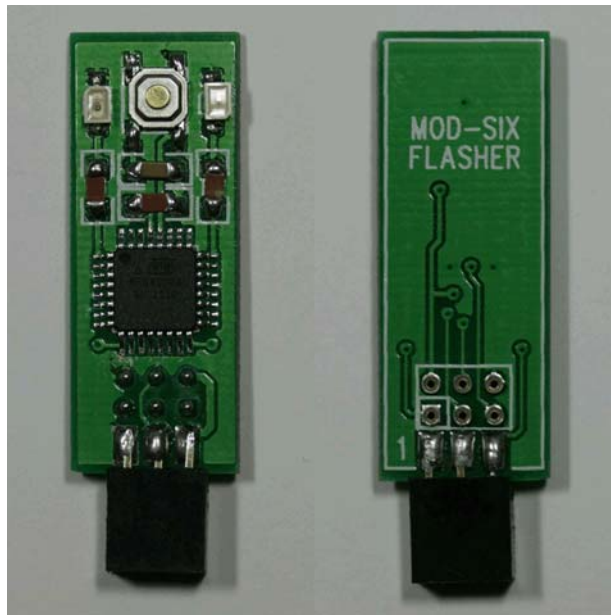
Note: **You may want to write down your clock configuration settings before proceeding, as the update process resets the clock to default values.**

To perform the update, disconnect the power cord from the clock. Remove the acrylic cover (you may want to use cotton gloves or some similar method to avoid getting fingerprints on the cover) and set it aside. Locate the programming connector on the CPU board, labeled "ISP J4". Note that if you have a GEN I CPU (labeled "CPU 1.0") with an RF-Link mezzanine

board installed, you will need to remove the mezzanine board in order to access the ISP connector.

Figure 2–2   Location of ISP connector on CPU
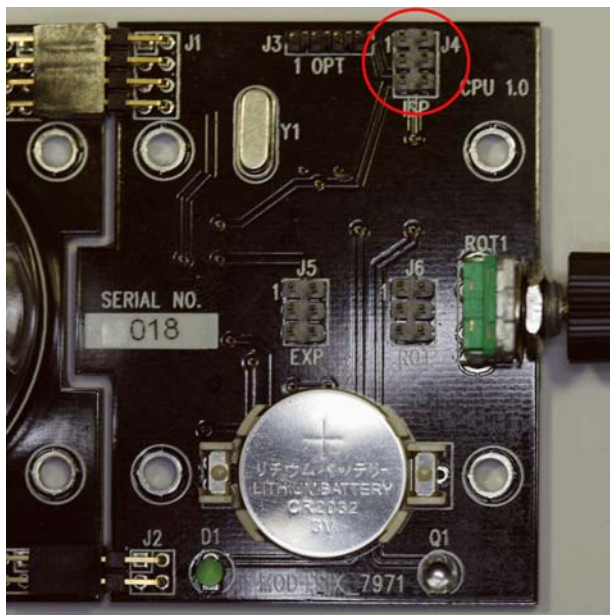
Note: **The above picture shows a GEN I CPU. While the layout of the GEN II CPU is somewhat different, the ISP connector is in the same location and orientation.**

Install the updating dongle on the CPU with the dongle components facing away from the tubes. Make sure that all 6 pins on the dongle are on the matching pins on the CPU, not offset by one pin.

Note: **The clock generates and uses high voltages to operate the tubes. Use caution to not touch any clock components other than the updating dongle when performing the update procedure.**

Figure 2–3   Dongle installed on CPU
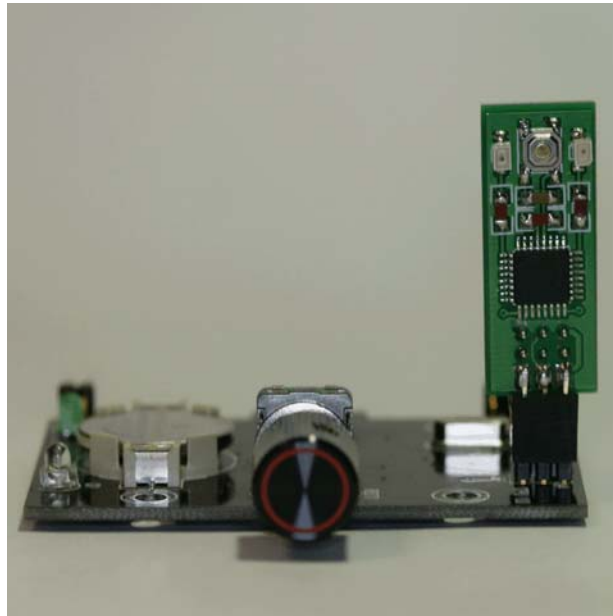
Apply power to the clock and wait for it to proceed through its normal startup. If the clock does not power on and display the normal startup messages, immediately disconnect the power and check your installation of the updating dongle.

Press the button on the top center of the updating dongle. It is rather small, and you may have trouble pressing it if you have large fingers. There should be an obvious tactile "pop" when it is successfully pressed.

The red and green LEDs on the dongle will light while updating is in progress. This normally completes within a few seconds. After the update completes, the green LED will remain lit to show a successful update and the clock will reset and display the new firmware version. If the red LED is lit instead, the firmware update was unsuccessful and you should press the button again to repeat the update procedure.

Note: **During the updating process, the tubes may go blank or freeze while displaying a message. This display may be brighter or dimmer than normal operation and does not indicate a problem with the update process.**

Once updating is complete, disconnect power from the clock and remove the updating dongle. If you removed the RF-Link mezzanine board, reinstall it, being careful to align all the connectors properly. Place the dongle back into its antistatic bag and reinstall the acrylic cover on the clock.

Apply power to the clock and set your desired configuration options. You may wish to review the new features in the latest User's Guide to see if there are any new options you'd like to explore.

2.1.1   Return of the updating dongle

Once you have confirmed that the firmware has been updated and all components are operating normally, please email badnixie@badnixie.com for the address to return the dongle to.

Note: **A single dongle and its packaging can be mailed in a regular envelope and should be under 1 ounce.**

Note: **Returning the dongle lets us send it to another clock owner and keep costs down.**

2.2   GPS repeater updating procedure

The GPS repeater firmware and lexicon (random word dictionary) may be updated using a Windows® PC, an Apple® Mac® (running OS X®), or any other system that supports USB Mass Storage devices such as systems running FreeBSD® or Linux®.

You will need the following in order to update the GPS repeater firmware:

- A computer of one of the types shown above and general familiarity with command line operations on that computer

- GPS repeater

- Updated firmware and lex_make utility (available from http://www.badnixie.com/MOD-SIX_Info_Page.html)

- USB cable with mini-B (*not* micro-B) connector on one end and a connector appropriate for your computer (normally full-size A, but this can vary) on the other end

The following figure shows the top of the USB repeater.

Figure 2–4   GPS repeater top view
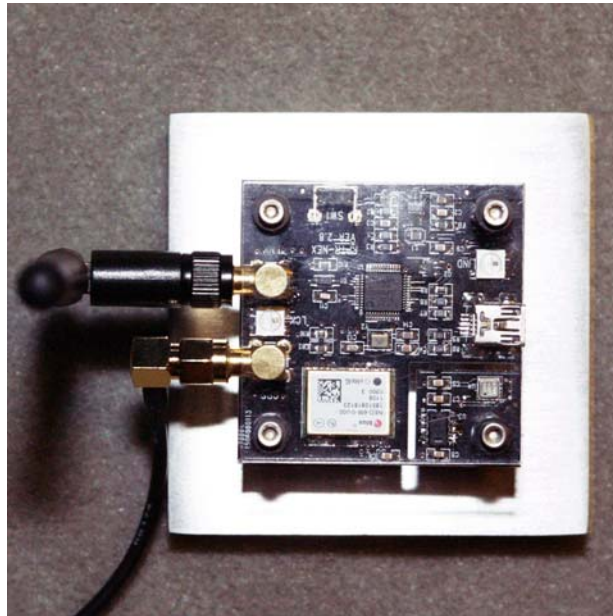
Unplug the USB power cable from the GPS repeater's USB connector (shown on the right side of the figure above). If necessary, unscrew the GPS antenna connector from the repeater (left side, lower). You may leave the radio antenna attached. Attach one end of the USB cable to your computer and while pressing and holding the button (top side, toward left) on the repeater, plug the other end of the USB cable into the mini-USB connector on the repeater.

At this point, no LEDs should be lit on the GPS repeater. If any LEDs are lit, it indicates that the repeater is not in updating mode. Disconnect the USB cable from the repeater, ensure that the button is pressed firmly, and repeat the operation.

Once the GPS repeater powers up in updating mode, your computer may or may not display a "Found new hardware" (or similar) message. The computer should automatically install any necessary driver software. If you are prompted to provide driver software, allow the computer to search the appropriate places for it. For example, Windows Update when using a Windows computer.

Note: **The GPS repeater (when in updating mode) acts as a standard USB Mass Storage device and no unusual drivers are needed. The same drivers that handle (for example) USB flash drives will work with the GPS repeater.**

If the GPS repeater does not illuminate any LEDs but the computer does not detect it, you may have a bad USB cable or perhaps the USB port you are using on the computer has been disabled. Some systems allow disabling groups of USB ports (although this is normally only done in

corporate environments). Try a port in a different group (for example, try a port on the back of the computer if you were using one on the front). You can also try using a different USB cable and / or a different computer.

Once you have the GPS repeater in updating mode and detected by the computer with any necessary drivers installed, it should appear as an additional disk drive. The method used to display this new disk drive will vary depending on the operating system used, but the computer will normally display some type of message indicating the name that was assigned, and / or add a new icon to the desktop. The "volume label" of the drive will be CRP DISABLD and the type of drive (possibly not shown) will be LPC1XXX IFLASH.

2.2.1   The firmware update file

One or more standard firmware files are provided in the update package (available from http://www.badnixie.com/MOD-SIX_Info_Page.html). You can use either one of the pre-built firmware files, you can modify the supplied lexicons and build your own firmware file, or you can create entirely new lexicons from scratch. Building customized lexicons is covered in Appendix A. The examples in this chapter assume you are using the provided firmware file named *RPTR-NEX_V36_LEX-BASIC.bin*, although the procedure is the same with a customized lexicon.

2.2.2   Updating procedure for Microsoft Windows

Open a command prompt window on the computer. This is normally done with the Start / Run menu sequence followed by typing *cmd* and pressing Enter, but can vary depending on the version of Windows installed. This should open a new window on the desktop. Use the mouse to click on that window to start using the command line. In the following example, we will assume that the drive letter assigned to the GPS repeater is I: although this will vary depending on the computer being used. We will also assume that the new firmware file is located in the *tmp* directory on drive C: and is named *RPTR-NEX_V36_LEX-BASIC.bin*.

- Type *dir i:* and press the Enter key to make sure you are on the correct drive

- Type *del i:firmware.bin* and press Enter to delete the old firmware file

- Type *xcopy c:\tmp\RPTR-NEX_V36_LEX-BASIC.bin i:* and press Enter to copy the file to the GPS repeater

Note: **If you receive an "Insufficient disk space" or similar error it means that you did not delete the firmware file in the previous step, or (unlikely) that the firmware file you are attempting to copy is damaged or too large.**

- Type *dir i:* and press Enter to verify that the file was copied to the repeater

```
C:\tmp>dir i:
 Volume in drive I is CRP DISABLD

 Directory of I:\

02/06/2009  10:10 AM             131,072 firmware.bin
              1 File(s)          131,072 bytes
              0 Dir(s)                 0 bytes free

C:\tmp>del i:firmware.bin

C:\tmp>xcopy c:\tmp\RPTR-NEX_V36_LEX-BASIC.bin i:\
C:\tmp\RPTR-NEX_V36_LEX-BASIC.bin
1 File(s) copied

C:\tmp>dir i:
 Volume in drive I is CRP DISABLD

 Directory of I:\

08/24/2015  08:23 AM             103,934 RPTR-NEX_V36_LEX-BASIC.bin
              1 File(s)          103,934 bytes
              0 Dir(s)            26,624 bytes free
```

Note: **If you disconnect the repeater from the computer and reconnect it, the name of the firmware file as well as its size and date/time will revert to firmware.bin, etc. This is to be expected.**

You should now close the terminal window. Use one of the supported Windows methods to "eject" the GPS repeater's drive letter. This can be done by clicking on the "Safely remove hardware" icon in the tray and then clicking on the drive letter associated with the GPS repeater's device. The remove hardware menu will normally also show the volume label (CRP DISABLD). You may also perform an eject function by double-clicking on the Computer (or My Computer in some versions of Windows) icon, normally near the top left of the Windows desktop. Then right-click on the drive letter of the GPS repeater and select Eject from the drop-down menu.

Note: **If the computer responds with some form of "Drive in use" error message, it is possible that you did not close the command line window you used to perform the firmware update or other activity on the computer (such as an anti-virus program) may be using the drive. In cases where Windows refuses to "let go" of the drive and allow you to eject it, you may just wait several minutes for any I/O operations to complete and then just unplug the USB cable from the GPS repeater.**

2.2.3   Updating procedure for Mac OS X

After you plugged the USB cable into the GPS repeater as described above, you should have an icon on your desktop labeled CRP DISABLD. If not, perform the checks described above to make sure the button on the repeater was pressed and that the USB cable and computer's USB port are working.

- Open the Terminal program, which is located in Utilities

- Click on the CRP DISABLD icon on the desktop to view the file(s) on the drive

- Type the command *rm* and press the spacebar

- Drag and drop the old repeater firmware file from the CRP DISABLED drive onto the terminal window

- Its path will be added to the end of the rm command, for example:
  MyComputer:~ myname$ rm /Volumes/CRP\ DISABLD/firmware.bin

- Confirm that the command line is correct and refers to the proper file and the GPS repeater drive, then press Return

Note: **Once a file is deleted with the rm command, the file is truly deleted and not recoverable. Make sure you are deleting the correct file!**

- Type the command *cp -av* and press the spacebar

- Locate the folder containing the new firmware file (we will assume it is located on the desktop in a folder named NEWFILE)

- Drag and drop the NEWFILE folder from the desktop into the terminal window to add the full path to the command line

- Press the Delete key once to remove the trailing space

- Type /*

- At this point the command should look similar to this:
  MyComputer:~ myname$ cp -av /Users/myname/Desktop/NEWFILE/*

- Press the spacebar

- Drag and drop the CRP DISABLD folder from the desktop onto the terminal window

- Type /

- The command line should now look similar to this:
  MyComputer:~ myname$ cp -av /Users/myname/Desktop/NEWFILE/*
  ↪ */Volumes/CRP\ DISABLD/*

Note: **The ↪ symbol indicates that this is part of the previous line, but split to fit the format of this manual.**

- After confirming that your command line looks like the above, press Return to copy the new firmware file to the repeater

- The computer should display something similar to this:
  /Users/myname/Desktop/NEWFILE/RPTR-NEX_V36_LEX-BASIC.bin
  ↪ *-> /Volumes/CRP DISABLD/RPTR-NEX_V36_LEX-BASIC.bin*

- Right-click on the CRP DISABLD icon on the desktop and select Eject to "eject" the GPS repeater from the computer

Note: **If you disconnect the repeater from the computer and reconnect it, the name of the firmware file as well as its size and date/time will revert to firmware.bin, etc. This is to be expected.**

Note: **The above procedure MUST be used on Mac OS X systems. A simple drag-and-drop operation will NOT work. This is due to the Mac's use of resource forks - a drag-and-drop copy will cause the repeater to try to load the resource fork instead of the actual firmware file.**

2.2.4   Updating procedure for other operating systems

It is not possible to enumerate methods for all of the possible operating systems that users may have. Review the Windows and Mac OS X procedures above for some background information. You will then need to perform the following general steps, in order:

- Mount the GPS repeater device

- Perform a directory operation on the device to make sure you are accessing the proper device

- Delete the firmware.bin file from the device

- Copy the new firmware file to the device

- Perform another directory operation to confirm that the new firmware file was properly copied

- Dismount the device

2.2.5   Reinstall repeater on clock

Unplug the GPS repeater from the computer's USB cable. Return the repeater to its previous location and reconnect the GPS antenna cable (if previously disconnected). The antenna cable only needs to be tightened finger tight.

Plug the USB power cable into the GPS repeater. The repeater should power up and display its firmware version via blink codes. For example, three red blinks followed by six green blinks would indicate firmware V36. The repeater will then send various pieces of information to the clock, which will display them. The following is a list of typical display items in order.

```
NEX 36
CH 77
BAR/RH
LEXCON
MYWRDS
21083
WORDS
```

This example shows GPS repeater firmware V36, radio channel 77, optional installed barometric pressure and relative humidity sensors, and a lexicon (random word dictionary) named MYWRDS ("my words") which contains 21,083 words.

Note: **Updating the repeater firmware does not change any previously configured LNKMNU / RFCHAN and LNKMNU / BAUD settings (in other words, you do not need to re-pair the repeater to the clock). The LED display mode is also unchanged from the previous setting.**

2.3   Keyfob updating procedure

Due to the small size of the keyfob circuit board and enclosure, it is not practical for most users to upgrade the keyfob firmware. Firmware updates will be handled by a "return for update" procedure if it becomes necessary to update the keyfob firmware.

3 Version history

Note: **Gaps in version numbers indicate unreleased development versions.**

3.1 Clock version history

- V06-06 - Version shipped with original GEN I clocks
- V07-07 - Version shipped with GEN II clock kits
- V07-09 - Version shipped with assembled GEN II clocks
- V07-53 - Version shipped with GEN IIv7 clocks
- V08-08 - Version shipped with GEN IIv8 (SLW) clocks, latest version

3.2 GPS repeater version history

- V10 - Version shipped with GEN II clocks and GEN I upgrade kits
- V26 - Version shipped with GEN IIv7 clocks
- V27 - Version shipped as an update for GEN IIv7 clocks
- V36 - Version shipped with GEN IIv8 (SLW) clocks with word dictionary, latest version

3.3 Keyfob version history

- V12 - Version for prototype (Sparkfun) hardware
- V14 - Version shipped with GEN IIv8 (SLW) clocks, latest version

A Building custom lexicons

A.1 Lexicon build procedure

A pre-built version of the lex_make utility for Windows systems is provided as part of the firmware update kit. The source code is provided and should compile and run on any system with a modern C compiler and runtime library.

Note: **Normally you will use the pre-built lex_make utility. The source code is provided in case you do not have a Windows system available. Instructions for compiling the utility are outside the scope of this document; refer to your operating system or compiler documentation for more information.**

The lex_make utility reads a configuration file and creates a custom firmware image based on the supplied configuration. Here is a sample config file named *lex_basic.cfg*:

```
rptr-nex_3.6.blob
RPTR-NEX_V36_LEX-BASIC.bin
BASIC
words/flw_dirty.txt
words/slw_dirty.txt
words/flw_basic.txt
words/slw_basic.txt
```

The first line contains the filename of the actual GPS repeater code "blob". The second line is the name of the firmware file to create. The third line is the display name of the lexicon which will be displayed on the clock when the GPS repeater powers up or is paired to the clock. The following lines, which can be as few as one or as many as you'd like, list the filenames of lexicons to be incorporated into the firmware. This example includes both the 4- and 6-letter "dirty" lexicons as well as the 4- and 6-letter basic lexicons. Additional lexicons can be found in the "words" subdirectory and example config files which use them are also provided.

The lexicons are stored in a special compressed format in order to increase the number of words which will fit in the repeater. The lex_make utility attempts to verify that the created firmware image will be small enough to fit in the repeater, however it does not guarantee that this is the case. If you add a very large number of words, you may exceed the storage capacity of the GPS repeater.

The following example shows the procedure to create firmware with the BASIC lexicon:

```
C:\tmp>dir/s
 Volume in drive C has no label.
 Volume Serial Number is 7A06-DFCD

 Directory of C:\tmp
```

```
08/25/2015  01:34 AM    <DIR>          .
08/25/2015  01:34 AM    <DIR>          ..
08/25/2015  01:34 AM    <DIR>          code_source
08/24/2015  08:22 AM              138 lex_basic.cfg
08/24/2015  08:22 AM              103 lex_clean_only.cfg
08/24/2015  08:22 AM              103 lex_dirty_only.cfg
08/24/2015  08:22 AM              140 lex_large.cfg
07/29/2015  04:14 PM          118,796 lex_make.exe
08/24/2015  08:37 AM            2,835 readme.txt
07/27/2015  10:29 AM           28,696 rptr-nex_3.6.blob
08/24/2015  08:23 AM          103,934 RPTR-NEX_V36_LEX-BASIC.bin
08/23/2015  10:31 AM               24 windows users can drop cfg file here.bat
08/25/2015  01:34 AM    <DIR>          words
               9 File(s)        254,769 bytes

 Directory of C:\tmp\code_source

08/25/2015  01:34 AM    <DIR>          .
08/25/2015  01:34 AM    <DIR>          ..
07/29/2015  04:14 PM            9,797 lex_make.c
               1 File(s)          9,797 bytes

 Directory of C:\tmp\words

08/25/2015  01:34 AM    <DIR>          .
08/25/2015  01:34 AM    <DIR>          ..
07/27/2015  10:07 AM           20,395 flw_basic.txt
07/29/2015  10:06 AM              145 flw_dirty.txt
03/15/2014  12:43 PM           27,051 flw_large.txt
07/27/2015  10:10 AM          112,058 slw_basic.txt
07/29/2015  10:50 AM              138 slw_dirty.txt
07/06/2015  09:43 AM          126,164 slw_large.txt
               6 File(s)        285,951 bytes

     Total Files Listed:
              16 File(s)        550,517 bytes
               8 Dir(s)  102,133,772,288 bytes free
C:\tmp>type lex_basic.cfg
rptr-nex_3.6.blob
RPTR-NEX_V36_LEX-BASIC.bin
BASIC
words/flw_dirty.txt
words/slw_dirty.txt
words/flw_basic.txt
words/slw_basic.txt

C:\tmp>lex_make.exe lex_basic.cfg
LEXICON MAKE UTIL 1.4, August 2015
Processed "words/flw_dirty.txt", 25 total words were processed from text file.
Processed "words/slw_dirty.txt", 16 total words were processed from text file.
Processed "words/flw_basic.txt", 4022 total words were processed from text file.
Processed "words/slw_basic.txt", 15783 total words were processed from text file.
Total lines processed = 1872
Total regular four letter words = 4022
Total regular six letter words = 15783
Total four letter dirty words = 25
Total six letter dirty words = 16
Total words = 19846
Now generating output bin file.
Lexicon "BASIC" output to file:"RPTR-NEX_V36_LEX-BASIC.bin".
Looks good to me. 103934 bytes were written to file.
```

Note: **The above example assumes the Windows command-line environment. Operation will be similar under other operating systems.**

A.2 Lexicon file format

The word files used by the lex_make utility have a simple format: 4 or 6 letters followed by either a space or the end of a line. The following sample shows the first few lines of the flw_basic.txt file:

```
aahs aals abas abba abbe abed abet able ably abos abri abut abye abys
aced aces ache achy acid acme acne acre acta acts acyl adds adit ados
adze aeon aero aery afar agar agas aged agee ager ages agha agin agio
```

Similarly, this sample shows the first few lines of the slw_basic.txt file:

```
aahing aaliis aarrgh abacas abacus abakas abamps abased abaser abases
abasia abated abater abates abatis abator abayas abbacy abbess abbeys
abbots abduce abduct abeles abelia abhors abided abider abides abject
```

To mark a word as "dirty", simply capitalize one or more letters of the word. For example, to mark the word abacus as dirty, simply change the first line of the above sample to:

```
aahing aaliis aarrgh abacas abaCus abakas abamps abased abaser abases
```

You could use ABACUS, Abacus, aBaCuS or any other combination of capital and lowercase letters - as long as there is at least one capital letter, the word will be marked as dirty.

Note: **There is no reason (other than convenience) that the dirty word lists are stored in separate files. You can merge them into a single file if you prefer.**

A.2.1 Suggestions for managing custom lexicons

We suggest that you create a new .cfg file using one of the existing ones as a template and that you also add your words to a separate lexicon file. Future updates to the GPS repeater firmware utility may overwrite the existing configuration and lexicon files. Using your own names for these files will ensure that your changes are preserved across updates. For example, you could create a file named *lex_mywords.cfg* with these contents:

```
rptr-nex_3.6.blob
RPTR-NEX_V36_LEX-MYWRDS.bin
MYWRDS
words/flw_dirty.txt
words/slw_dirty.txt
words/flw_basic.txt
words/slw_basic.txt
words/my_words.txt
```

You would then add your words to the *words/my_words.txt* file.

You may add foreign words to the lexicon files if you so desire. However, those words should be modified (if necessary) to contain only the English letters A through Z as the tubes in the clock can only display English letters.

Note: **When you receive a new firmware update package, you should check to see if the version of the code blob has changed, and make the corresponding change to your .cfg file (the first and second**

lines). This ensures that your custom firmware has the lastest GPS repeater code included.

B Advanced updating techniques

The above clock updating procedure presumes that you are using the supplied updating dongle when updating the firmware. Firmware updates are also available (upon request) as .hex files for those who have their own programming capability. In this case, the firmware is directly installed onto the clock without using an updating dongle as an intermediary. As a minimum, you will need updating software such as AVRDUDE (http://www.nongnu.org/avrdude) or eXtreme Burner (http://extremeelectronics.co.in/software/BurnerAVR) as well as a compatible programmer such as the USBasp (http://www.fischl.de/usbasp). The choice of programming hardware and software is up to you. However, not all combinations (in fact, very few) have been tested by us so some experimentation may be needed. Here are some pointers which may be useful:

- The CPU on the clock is an ATMEGA168A and should be programmed at 5V.

- Many USBasp devices come with a 10-pin programming connector. In that case, you will need a 10-pin to 6-pin adapter for programming the MOD-SIX clock.

- On some programmers / adapters, the 6-pin connector has a large keying tab which may interfere with seating the adapter on the ISP connector.

- The dongle's checks for appropriate firmware type do not apply when directly programming the MOD-SIX clock. Therefore, it is definitely possible to flash something that doesn't work. As long as you do **NOT** reprogram the fuses, you should be able to recover by flashing a valid firmware image.

- If you are at all uncertain about the correct orientation / pinout of the ISP connectors on the clock, refer to the schematic and board artwork package provided with the clock.