SHDesigns Ethernet Downloader for
Z-World Rabbit Boards

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1.0 INTRODUCTION

The Ethernet Download Utility allows Rabbit-based TCP/IP boards to upgrade the FLASH code in the field without the serial programming cable. This functionality consists of 3 parts:

1. A small library included in a user program: UDPDOWNL.LIB.
2. A small RAM-based program that downloads the new code and programs FLASH.
3. The PC Utility to find and program boards.

Unlike other solutions for network downloading, this implementation requires little changes to a users code. There are no hardware changes or library changes for most Rabbit products..

2.0 HOW IT WORKS

The Z-World solutions impose restrictions on the hardware and software. Even their serial solutions require changes to the libraries and dividing FLASH in half.

The main problem is their network libraries. There is no way to pare them down small enough to fit in RAM in a running system with 128K of RAM. If a program could be built small enough, it could be downloaded to xmem, copied to root and run.

This solution resolves this problem by writing a stripped-down network stack. UDP sockets are simple to implement. To support UDP only the following is needed:

1. Basic IP support (source and destination headers.).
2. ARP support (reply only).
3. UDP packet support.

The stack also provides ICMP support to allow 'Pings' for debugging.

Since the downloader operates as a client and not as a server, ARP is simple. It only needs to respond to a request. It does not need to use ARP to find the PC application MAC address. It just replies back to the MAC address that the packet came from.

Packet buffering is also simplified. The stack never generates a packet by itself. It just receives a packet, processes it, and then optionally modifies it and sends it back.

Source network routing is ignored. The stack assumes that it will only have to reply back to a local LAN IP. Actually, the stack will work through routers and sub nets. This is handled automatically by a router. The UDP stack just sends the replies back to a router with the PC application IP address and the router MAC address. The router does all the work. This stack also does not need to know the netmask. Since it is a client-only app, it does not need to find the network segment. The router and PC application will take care of netmasks and routing.

The “Search” function only works on the local segment as broadcasts are not passed through routers.

The entire RAM program is less than 21k.

Now that we have a small RAM program, the rest is fairly easy to implement. The library routine just has to allocate a buffer in xmem to store the program. After the RAM loader code is downloaded and a ‘RUN’ command is received, it copies the program to root RAM, re-maps RAM to 0, and reboots to the new code. Although this seems simple, the code is complicated by the way DC maps RAM.

The library also has additional functions. One is to preserve the IP address of the board. Since the entire board is reset, the network needs to be reinitialized. The IP is passed in RAM to the new program. An additional function of the library is to respond to “Query” commands. The query command is a broadcast on the LAN for all board to identify themselves. Each board that supports the download function will reply with a user-supplied string. This allows the PC utility to identify boards by name. The user can include the current version in the string to allow the PC user to identify boards that need upgrading.

The library code is quite small, about 1k of code and about an ETH_MTU (system maximum packet size) of root RAM. It also requires one UDP socket for communications.

The library uses no extra xmem memory until a request to download the RAM loader is received. It will then allocate enough xmem to store the RAM program. The user program is notified that a request has been received and so it can free up xmem if needed. Only programs that use all of xmem would need to do this. When the RAM program is included in Flash, no xmem is needed. The library just needs to copy the program to 0 and jump to it.

The library and the download utility report their status to the PC program. They will report that they need the Ram loader, have the RAM loader in Flash or are running it. All memory allocation and code blocks are acknowledged.

3.0 IMPLEMENTING THE LIBRARY

3.1 Dynamic C Changes

udpdownl.lib and udpdnld.h needs to be added to the DC compiler LIB.DIR file for the compiler to locate the library. I.e. if the files are in “C:\program files\rabbit\mylibs” add the following lines to the LIB.DIR file in the main compiler directory:

C:\program files\rabbit\mylibs\udpdownl.lib
C:\program files\rabbit\mylibs\udpdnld.h

There are no changes required for the Dynamic C libraries. This library has been compiled with version 7.21 of Dynamic C through version 9.24. It should work with any 7.2x compiler or later.

3.2 User Program Changes

In the user's program the changes are simple. Just add the following code:

You must define at least 1 additional UDP socket and buffer:
```
#define UDP_SOCKETS 1     // allow enough for downloader and DHCP
#define MAX_UDP_SOCKET_BUFFERS 1
```

Note: DHCP may need additional UDP sockets and buffers

After the "#use dcrtcp.lib" add the following line:

```
#use udpdownl.lib
```

In the main code add the following functions:

After the "sock_init()" call add:

UDPDL_Init(string)

Where "string" is a string to report back to the PC. An example would be:

UDPDL_Init("XYZ Corp. Controller Version 1.0.3a");

Then when the "search boards" is done in the PC app. It will show this string on the screen. The lib only stores a pointer to this string, so it must be static.

If NULL is passed as the string, the board will report: "Rabbit Board UDP Download". UDPDL_Init() will return 0 if success. The only reason it would fail is if there are not enough UDP buffers or sockets.

Note: if the IP address of the board is changed after UDPDL_Init() is called, you will have to call UDPDL_Init() again to update the UDP socket. If this is not done, the board may respond to the old address but will fail download as the new addressis reported to the RAM loader.

In the main loop of the program, the function "UDPDL_Tick()" needs to be called periodically. Normally this is where the tcp_tick() is called. It should be called at least once a second for best results.

UDP_Tick() normally returns 0. When the PC requests a buffer for the RAM code, it will return 1. If the user program has allocated all of xmem, it can use this flag to know when it needs to free

some xmem for the downloaded program. Normally applications do not use all of xmem and they can ignore this.

Once UDP_Tick() has returned 1, the user program will soon be stopped. The user program may need to shutdown features or notify other apps that it will be shutting down.

3.3 Including the RAM loader in FLASH

Note: the RAM loaders only provide recovery from a power loss if the RAM loader is included in flash.

The library can include the RAM loader in FLASH. This requires about 21k more of FLASH memory. This is stored in the xmem area. The library will then not need any xmem RAM to store the Ram loader.

To include the RAM loader add the following define before the "#use UDPDOWNL.LIB line:

```
#define UDPDL_LOADER "x:/path/to/file/PDL-Generic.bin"
```

The UDPDL_LOADER define is used in the library as follows:

```
#ximport UDPDL_LOADER _udp_dl_loader
```

The UDPDL_LOADER define is the file name to ximport. Dynamic C has problems with paths for ximport. Sometimes it will work with just the file name in quotes. But it often does not use the right directory. It is usually better to use the full path to the loader.

This file must not be encrypted.

3.4 The Sample program

In the Sample directory is a file called DLTest.c. This is basically a program that does nothing except allow a user program to be loaded. It is a good idea to test with the sample first to make sure the environment is configured properly.

Compile the program to FLASH and run it. Note: do not try to run the downloader under the debugger. The DC IDE will reset the board when the RAM loader tries to run and report a communications error.

Download to flash and reset the board then run the PC utility. You should be able to download one of your regular .bin files to the board. This will then run your FLASH bin file. If your .bin file does not have the library functions included, you will not be able to download again.

Make the changes to your source as shown in the previous sections. Then once you program it to flash, any new version can be downloaded via the PC utility.

Compiling a .bin file must be for the desired board. Be sure to define the targetless compile option of the compiler for your baord. Otherwise the .bin file will not work.

4.0 RAM DOWNLOAD PROGRAM

The RAM program is supplied pre-compiled. Versions are available for most Rabbit boards.

SHDesigns will provide the binary for any of the Rabbit-based boards. Source is not provided. This is mainly to prevent supporting many different loaders. The RAM loader is written using the Softools ANSI C compiler. If a custom downloader is required, you will need to purchase the RAM loader source for the Softools version and use the Softools compiler to build a RAM loader.

4.1 Generic RAM Loaders

These RAM loaders are generic, they should work on any board. The files are as follows:

PDL-Generic.bin - Main version
PDL-Generic-D.bin - Includes debug output on port A at 115,200 baud
PDL-Generic-IO.bin - Same as the first, but forces PORT E high.
PDL-Generic-IO-D.bin - Same as the second, but forces PORT E high.
PDL-Asix.bin - Minimal version for boards with the ASIX ethernet chip
PDL-Realtek.bin -Minimal version for boards with the Realtek ethernet chip
PDL-SMSC.bin Minimal version for boards with the SMSC ethernet chip

Note: The code to recover from a power loss or reset durning a download is only enabled if the RAM loader is included in flash. Unless Flash space is limited, the RAM loader should always be included in flash.

The PDL-Generic.bin would be the preferred RAM loader. The -D version can be used to debug problems. To debug the output, connect the “Diag” connector of the programming cable to the board and run something like Hyperterminal at 115200 baud, no parity and no handshaking.

The Asix, Realtek and SMSC versions can be used to minimize size a bit.

The “-IO” versions for PORT E high. This is needed for boards that use port E chip select outputs but don’t have the needed pull-ups on them. This has been seen on several user boards. Chip selects without a pullup will even cause the RFU to sometimes fail.

There are also board-specific loaders. These are PDL-RCMxxxx.bin files. These are the generic loaders with the ID forced to a specific value. The RAM loader uses the ID to determine the correct Ethernet driver to use. These board-specific RAM loaders are intended for custom boards that use non-standard Ids but have similar hardware to one of the standard ZW boards.

4.2 Old RAM loaders

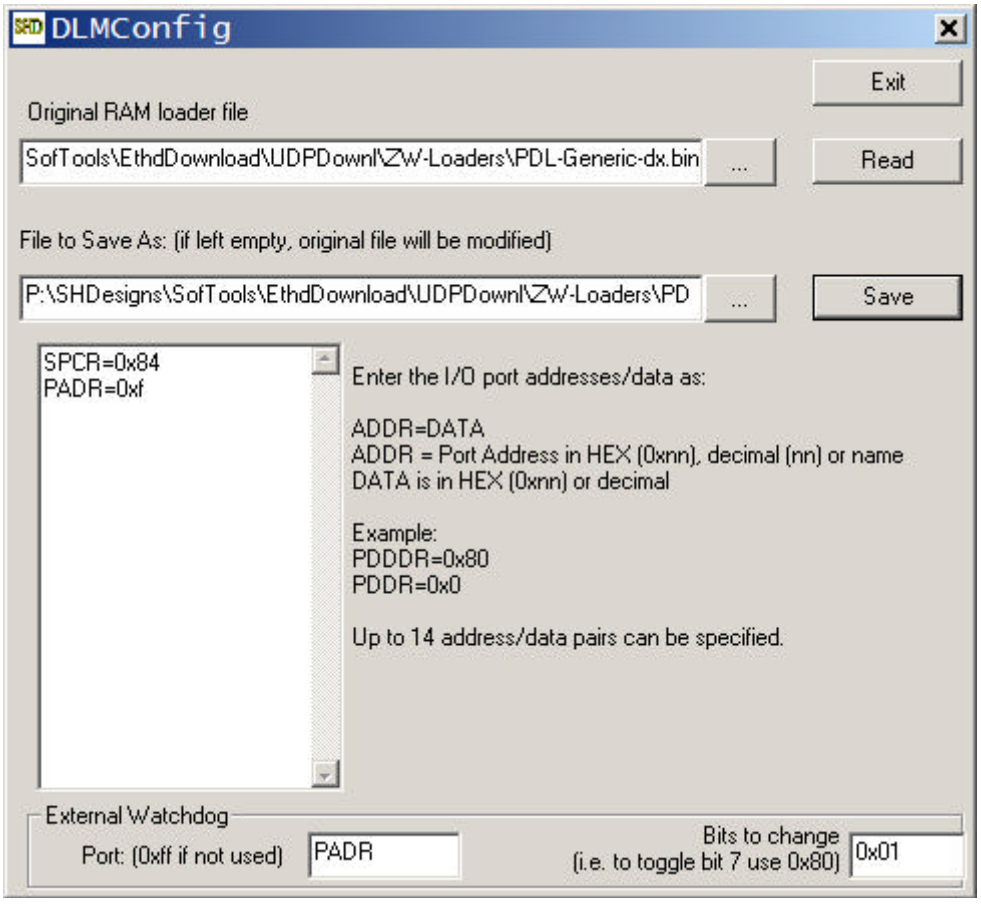
These loaders are no longer supported.
The web site has the older loaders. These are larger and do not use as good error recovery. These are in the “OldLoaders” area of the website. The old RAM Loaders are named as follows:

PDL-board#.bin
Where ‘board#’ is the Z-World board number. I.e PDL-RCM2200.bin for the RCM2200. The 2200 module will work with Rabbit 2k-based boards. This will work on all of the 22xx modules that use either the first 256k flash or both 256k flash chips for code or data.

4.3 Customizing the RAM loader

Note: This only applies to RAM loaders dated 3/31/07 or later.

The RAM loaders can be patched to add extra initialization and toggle an I/O bit to keep an external watchdog acive. This is done with the DLMConfig.exe utility:



The steps are as follows:

1. Select one of the Generic RAM loaders as the input file. Click on “Read” to load the .bin file. Note the “...” button can be used to browse to select the file.
2. Select the output file, if not entered, the original file will be modified.
3. Enter the I/O port addresses and data, each on one line. The format is ADDR=data where ADDR is a hex value or a port name and data is hex (0xnn) or decimal (nn).
4. If a pin needs to be toggled, enter the port in the External Watchdog area. Enter the bits to change. This value will be exclusive-OR-ed with the port every 100ms.
5. Click on “Save” to create the modified RAM loader.

Then include this modified RAM loader in your source.

5.0 ENCRYPTION

The download utility version 1.1 and higher supports encrypted .bin files. This prevents users from using the bin files with any other downloader.

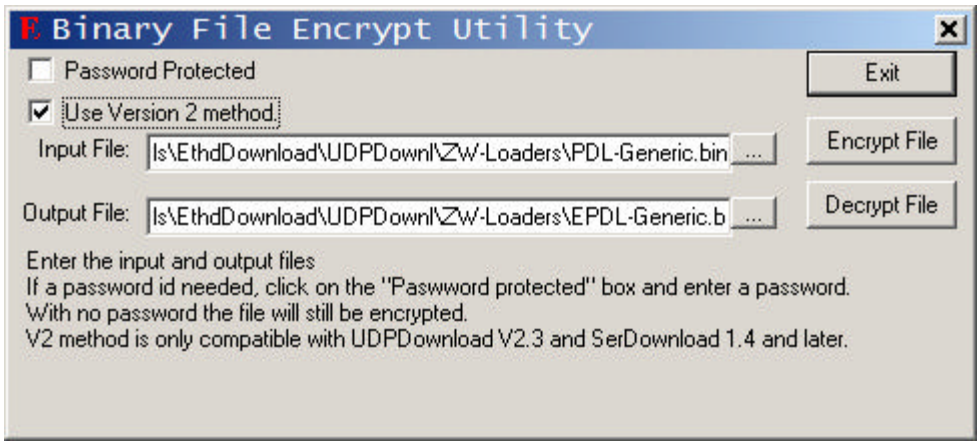
Encryption is done as follows:

1. A small header is added to the file
2. If a password is used, a encryption key is generated. If no password is used, a pre-defined key is used.
3. A second random key is generated.
4. This second key is encrypted with the password key.
5. The .bin file is appended and encrypted with the second key.

The password is not saved in the header. It is used to generate a unique key. There is no way to recover the password from the key. Thus, there is no information in the header on the size of the password. Unlike other encryption methods, the strength of the encryption does not depend on the length of the password.

The encryption keys are 96-bits long. The header starts with the string “Encrypted program file.” This identifies the file as encrypted. If a user types the file from a command prompt, they will see only this string.

A utility called EncryptBin.exe can be used to encrypt user files.



If the “Password Protected” check box, a password can be entered in the field to the right.

The “Use Version 2 method” should be checked as it provides better protection. Without this checked, an incorrect password may be recognized.

The input and output file fields can be entered or the “...” buttons on each can be used to browse for the files.

Pressing “Encrypt File” will encrypt the file. The status area in the bottom of the dialog will indicate a successful conversion.

Note: There is a difference in security between having no password and an empty password. If the “Password Protected” check box is not checked, the user will not be prompted for a password. If the box is checked and no password is entered, the user will still be prompted for a password and the loader will accept an empty password.

The “Decrypt file” button will decrypt a file, no password is needed.

Since this utility can decrypt a file with no password, it should not be distributed to end users.

6.0 Password Protecting the PC Utility

The 1.4e and later versions of the program allows it to be password protected. This was asked for by one of my clients to prevent end users from running the program.

The only way to set the password is to edit one of the resources in the file. I use “resource hacker” that can be found at: http://www.users.on.net/johnson/resourcehacker/
In the resources edit the following string entry:

String Table --> 7 --> 1033 --> 102

It should have a string of “-None-”. Change this to the required password and the program will not run until this password is entered