Application Note

Data Communication with eZ80F91 MCU Using the User Datagram Protocol

AN021002–0108

Abstract

This application note describes how to use the User Datagram Protocol (UDP) to exchange data, typically less than 1500 bytes, between Zilog's eZ80F91 webserver and a PC client. The eZ80F91 web server is Zilog's eZ80F91 MCU that executes the Zilog TCP/IP stack (ZTP), which supports the UDP protocol. This application note describes a client-side implementation that sends a user input, and a server-side implementation that receives the client request and sends an appropriate response.

The source code file associated with this application note, `AN0210-SC01.zip`, is available for download at www.zilog.com.

Note: *The source code associated with this document is intended for use with the ZTP v1.4.0. To develop your application with earlier versions of ZTP, refer to Data Communication with the eZ80F91 MCU Using the User Datagram Protocol application note (AN0179), available at* www.zilog.com.

Zilog® Product Overview

This section provides a brief overview of Zilog products used in this application note, which includes the eZ80Acclaim*Plus!*™ microcontrollers and the full-feature ZTP software suite.

eZ80Acclaim*Plus!* MCU Family Overview

The eZ80Acclaim*Plus!* family of microcontrollers includes Flash and non-Flash products. The Flash-based eZ80Acclaim*Plus!* MCUs, device numbers eZ80F91, eZ80F92, and eZ80F93, are an exceptional value for customers designing high performance embedded applications. With speeds up to 50 MHz and an on-chip Ethernet MAC (eZ80F91 only), you have the performance necessary to execute complex applications supporting networking functions quickly and efficiently. Combining on-chip Flash and SRAM, eZ80Acclaim*Plus!* devices provide the memory required to implement communication protocol stacks and achieve flexibility when performing in-system updates of application firmware.

Zilog also offers two eZ80® devices without Flash memory: eZ80L92 and eZ80190 microprocessors.

ZTP Overview

ZTP integrates a rich set of networking services with an efficient real-time operating system (RTOS). The operating system is a compact preemptive multitasking, multi threaded kernel with inter-process communications (IPC) support and soft real-time attributes. Table 1 lists the standard network protocols implemented as part of the embedded TCP/IP protocol stack in ZTP.

Table 1. Standard Network Protocols in ZTP

HTTP	TFTP	SMTP	Telnet	IP	PPP
DHCP	DNS	TIMEP	SNMP	TCP	UDP
ICMP	IGMP	ARP	RARP	FTP	

Many TCP/IP application protocols are designed using the client-server model. The final stack size is link-time configurable and determined by the protocols included in the build.

Discussion

This section provides a brief overview of the User Datagram Protocol (UDP) protocol and lists the UDP-related API functions available in ZTP. ZTP includes UDP among other protocols.

User Datagram Protocol

UDP is an IETF standard transport layer protocol that runs on the IP layer of the TCP/IP stack. It is defined by RFC 768 as a protocol for sending messages to application programs with a minimum of protocol mechanisms. The RFC also mentions the inherent unreliable nature of the UDP protocol—it is transaction-oriented but datagram delivery is not guaranteed. Therefore, UDP applications transfer data between a client and server without any acknowledgement of the communication. In such a case, user-applications must ensure that messages are sent and received reliably by using an error recovery method. Thus UDP provides a connection-less method that is fast but inherently less reliable than data transfer over TCP sockets. However, for some requirements, UDP proves to be a boon, because data bytes can be easily exchanged between networked nodes.

Some of the applications that use UDP by default are Ping, SNMP and DNS. Because the time required for transferring data via UDP is less, transport of audio and video data streams over UDP in embedded systems is gaining popularity.

A standard UDP datagram consists of a source and a destination IP address, the type of protocol and the data length. Figure 1 displays the UDP datagram and its components.

Note: *For more details on ZTP, see documents listed in* References *on page 9.*

UDP API Functions Available in ZTP

Table 2 lists the API functions available for applications intended to use the UDP layer of ZTP.

Table 2. ZTP-UDP API Functions

API Name	Description
`Open()`	Opens a UDP socket for Data transfer
`Control()`	Provides UDP-specific device control function
`Read()`	Receives a UDP data packet
`Write()`	Sends a UDP data packet
`Close()`	Closes the UDP socket signalling the end of communication

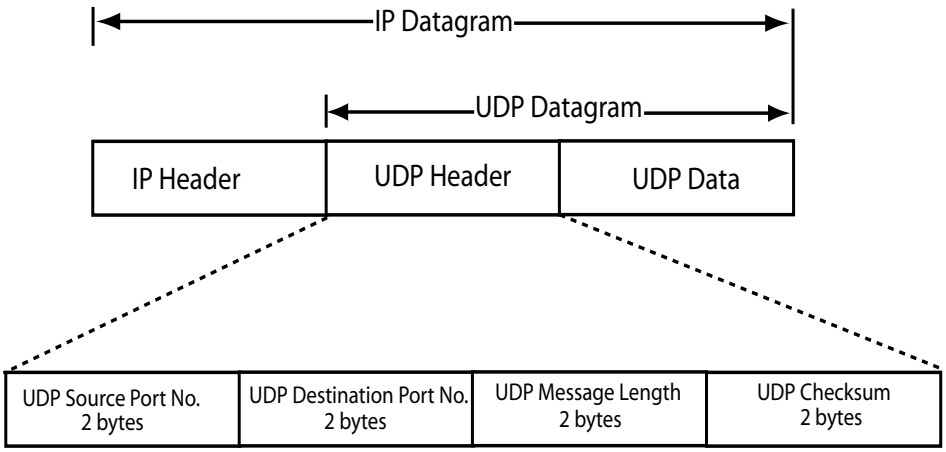

Figure 1. The UDP Datagram

Developing the UDP Application

This section describes how to interface the eZ80F91 MCU with the PC to exchange the UDP data packets.

Hardware Interfacing

Figure 2 displays the block diagram showing the setup connecting the eZ80® Development Platform and the PC. The eZ80F91 MCU contains the ZTP Software Suite which makes it function as a web server.

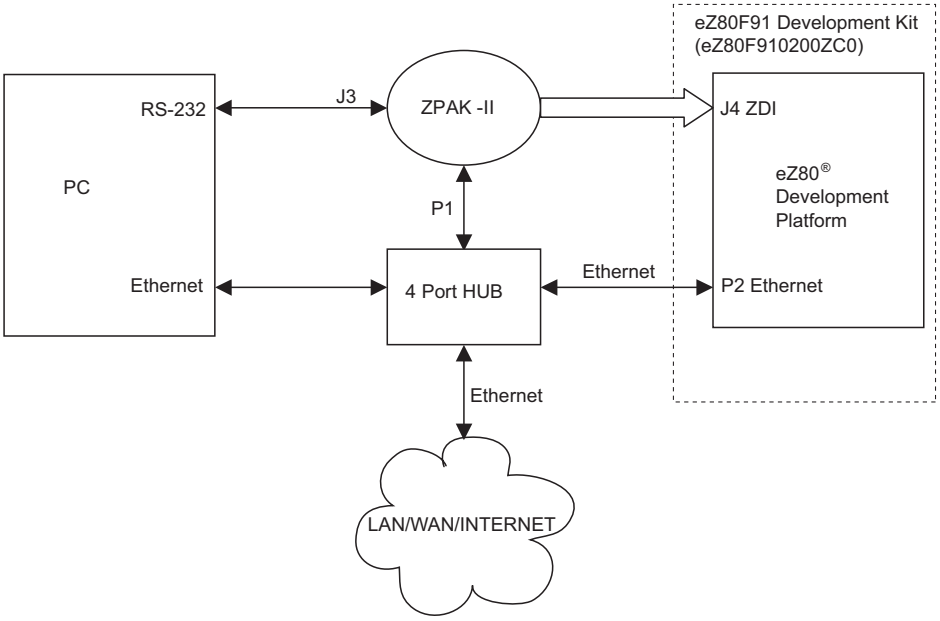

Figure 2. Block Diagram of the Setup Connecting the eZ80F91 MCU and the PC

Software Implementation

The software implementation consists of two parts:

- Client-side Implementation
- Server-side Implementation

Client-side Implementation

The file, `Clientmain.c` (available in `AN0179-SC01.zip` file), runs on the PC client and is coded in ANSI C. For details of this implementation, see Client-Side Implementation. Figure 3 on page 10 displays the flowchart for the client-side software.

Server-side Implementation

The server-side software is implemented as a thread in the ZTP stack, and runs on the eZ80F91 web server. For details on this implementation, see Server-Side Implementation on page 4. Figure 3 on page 10 displays the flowchart for the server-side software. The client and server exchange data messages in the form of UDP datagrams.

Following sections describe the details of the client-side and the server-side implementations:

- Client-Side Implementation
- Server-Side Implementation

Client-Side Implementation

The following tasks consists of client-side implementation present in the `Clientmain.c` file:

- The standard APIs available with the Microsoft Windows® TCP/IP stack are included in the `Clientmain.c` file using the statement:

  `#include <winsock2.h>.`
- A buffer size of 100 bytes is allocated for the incoming and outgoing UDP messages in the variables `inBufferSize` and `outBufferSize`, respectively. Initialization of the Windows-side socket is accomplished using the `WSAStartup()` function; an error message is printed on failure to initialize.
- The eZ80F91 server address (in IPv4 format) is stored in the variable `servAddr.sin_addr.s_addr`. This IP address is assigned by the LAN network system administrator for every PC on the network. The `Clientmain.c` file contains a default IP address that must be changed to the user-specific IP address.
- The server-side UDP port number (default value = 5009) is stored in the variable `servAddr.sin_port` and can be changed to any other available port number.
- The client-side port number (default value = 5006) is stored in the variable `local.sin_port`. This default value can be changed according to the availability of port numbers on your PC.

When the `Clientmain.c` program is executed, a menu, requesting input is displayed at the DOS prompt. The input that is entered is formatted into a UDP packet/datagram and sent to the server using the ZTP-UDP API `send()`.

Figure 1 on page 2 displays a typical UDP datagram formed by the `send()` API.

The Server-Side Implementation details how the server handles the UDP datagram. The `recv()` API is used to collect the response from server; the response is stored in the buffer memory. When the client successfully receives a response from the server, the socket is closed and the received data is printed in the DOS window along with the number of bytes received.

Server-Side Implementation

The following tasks comprise the server-side implementation present in the `udp_ez80.c` file. The `udp_ez80.c` file contains the `test()`, `udpnormal()`, and `normal()` functions.

- The main thread executes the `test()` function on initialization. This action sets up a command, `udptest`, in ZTP's shell structure.
- The `udptest` command, along with an argument, calls the `udpnormal()` function, which creates a thread—the `normal()` function.
- The IP address of the user's client PC and the UDP port numbers for both the client PC and server are supplied as arguments to the ZTP-UDP API `open()` function.
- The server sends a message on receiving user input for the menu displayed at the Windows DOS prompt. The message—*This is message number one/This is message number two*—is sent by the server depending on the number entered by the user.
- This message is first copied into the `xgram` data structure and then sent using the ZTP-UDP `write()` API. The size of the UDP packet is determined from the argument provided with the `udptest` command in HyperTerminal (see Executing the UDP Demo Application on page 8). The run-time errors, including socket open error, memory unavailable or UDP read and write failure, are printed

in the HyperTerminal along with the error codes to simplify debugging.

Adding and Integrating UDP Demo-Specific Files to ZTP

The UDP Demo described in this application note requires the eZ80® Development Platform with an eZ80Acclaim*Plus!*™ microprocessor/controller and the ZTP stack. For the Demo execution, some of the files specific to the demo must be added and integrated to the ZTP stack before the stack is downloaded onto the eZ80® Development Platform. This section describes how to add the Demo files to the ZTP stack.

The Demo files are C (*.c) files and must be added to the ZTP project files in the `AN0210-SC01.zip` file available at www.zilog.com.

The ZTP stack is available at www.zilog.com and can be downloaded to a PC with a user-registration key. ZTP can be installed in any location as specified by the user; its default location is `C:\Program Files\ZiLOG`.

Note: *See Software Requirements on page 7 for ZDS II and ZTP version used in this application.*

Follow the steps below to add and integrate the UDP Demo files to the ZTP stack:

1. Download ZTP. Browse to the location where ZTP is downloaded, and open the `\website.Acclaim` folder located in the path `..\ZTP_1.4.0\ZTP\SamplePrograms`.
2. Download the `AN0210-SC01.zip` file and extract all its contents to a folder on your PC (this folder is referred to as `\UDP_Demo` folder in the rest of the application note).
   The `\UDP_Demo` folder contains the following folders:

   ```
   \Server side_Demo
   \Client side_Demo
   ```

3. Copy all the *.c, and *.h, files located in the `\UDP_Demo\Serverside_Demo` folder into the `..\ZTP_1.4.0\ZTP\SamplePrograms\ZTPDemo` folder.
4. Launch ZDS II for eZ80Acclaim!® and open the `ZTPDemo_F91.pro` file available in the path `..\ZTP_1.4.0\ZTP\SamplePrograms\ZTPDemo`.
5. Add the `udp_ez80.c` file located in the `..\ZTP_1.4.0\ZTP\SamplePrograms\ZTPDemo` folder to the `ZTPDemo_F91.pro` project.
6. Open the `udp_ez80.c` file from within ZDS II. Change the client IP address and port number in the following line of code:

   ```
   if((dev = open(UDP,
   "192.1.6.75:5006",(char *) 5009))
   == SYSERR)
   ```

   where, `192.1.6.75:5006` must be substituted with the IP address and the port number of the client machine being used, and `5009` must be substituted with the port number assigned to the eZ80F91 web server.
7. In the `ZTPConfig.c` file, look for the following structure definition:

   ```
   struct commonServers csTbl={

   "172.16.6.28",// Default Timer Server
   "",// Default rfs server
   "",// Default File Server -
   // Not currently Used
   "172.16.6.194"// Default Name Server
   };
   struct If ifTbl[MAX_NO_IF]= {

   // interface 0 -> Ethernet
   Configuration
   {

   &usrDevBlk[0],// Control block for
   // this device
   ETH,// interface type
   ETH_MTU,// MTU
   ETH_100,// Speed can be ETH_10,
   // AUTOSENSE
   "172.16.6.200",// Default IP address
   "172.16.6.1",// Default Gateway
   ```

```
0xffff0000UL// Default Subnet Mask
}
```

The structures above contain network parameters and settings (in the four-octet dotted decimal format) specific to the local area network at Zilog® as default.

Modify the above structure definition with appropriate IP addresses within your local area network (for details on modifying the structure definition, see ZTP documents listed in References on page 9).

8. In the `main.c` file, add the following function prototypes and global variables:

```
//prototype functions
 extern void test (void);
```

9. Add the `test()` function, after the `shell_init(TTYDevID)` function in the `main.c` file.
10. Open the `eZ80_HW_Config.c` file and change the default MAC address (provided by ZTP) such that each eZ80® Development Platform on the LAN contains a unique MAC address. The following line of code is present in the `eZ80_HW_Config.c` file:

```
const CHAR
f91_mac_addr[ETHPKT_ALEN] = {0x00,
0x90, 0x23, 0x00, 0x0F, 0x91};
```

In the 6-byte MAC address shown above, the first three bytes must not *be* modified; the last three bytes can be used to assign a unique MAC address to the eZ80® Development Platform.

11. Open the `ZTPConfig.c` file. For this application, Dynamic Host Configuration Protocol (DHCP) is disabled; therefore, ensure that:

```
byte b_use_dhcp = FALSE
```

12. Save, compile and build the `ZTPDemo_F91.pro` project.

Compiling and Building the Client-Side Project

Follow the steps below to compile and build the client-side project:

1. Launch the Microsoft Visual C++ IDE and open the file `Clientmain.c` (located in the `\UDPDemo_Source_code\Client side_Demo` folder).
2. Set the IP address and the port number of the eZ80F91 web server in this file, as explained in Client-Side Implementation on page 4.
3. In Microsoft Visual C++ IDE go to **File → New → Projects.**
4. Select **Win32 Console Application** from the list in the left panel and provide a project name and path for the client-side project.
5. Click **OK** button. The **Win32 Console Application** dialog box is displayed.
6. Select **An Empty Project** option in answer to the question on the kind of project to be created; click **FINISH** button to close the **Win32 Console Application** dialog box.
7. Go to **Project → Add to Project → Files**. Browse for the `Clientmain.c` file and add it to the client-side project.
8. Go to **Project → Settings → Link** and add the library file, `ws2_32.lib` in the **Object/ library module** text field.
9. Compile and build the client-side project.
10. Save and close the client-side project.

See Executing the UDP Demo Application on page 8 to execute the client-side program.

Demonstrating the UDP Application

This section provides the requirements and instructions required to setup the UDP Demo and run it. The Demo demonstrates the exchange of datagrams between the eZ80F91 MCU running ZTP (with UDP services) and a PC client running the UDP services of Microsoft Windows-based TCP/IP stack.

Setup

The basic setup to assemble the Demo is displayed in Figure 2. This setup illustrates the connections between the PC, LAN/WAN/Internet and the eZ80® Development Platform with the eZ80F91 Module.

The hardware and software requirements include:

Hardware Requirements

The hardware requirements to execute the UDP Demo are as follows:

- eZ80F91 Development Kit includes the following:
  - eZ80® Development Platform
  - eZ80F91 Module
  - 9 V DC Power Supply
  - ZPAKII Debug Interface Module, with power supply
  - 4-port 10 BaseT Ethernet Hub with power supply
- PC with HyperTerminal and Microsoft Visual C++ IDE

Software Requirements

The software requirements to execute the UDP Demo are as follows:

- Zilog Developer Studio II—IDE for eZ80Acclaim!® 4.8.0 (ZDS II-IDE 4.8.0)
- Zilog TCP/IP Software Suite (ZTP v1.4.0)
- Microsoft Visual C++ IDE to build the client-side program

Settings

The HyperTerminal and Jumper settings are provided below:

HyperTerminal Settings

Set HyperTerminal to 57.6 Kbps Baud, 8-N-2, with no flow control

Jumper Settings

For the eZ80® Development Platform:

- J2 is ON
- J3, J7, J11, J20, J21, J22 are OFF
- For J14, connect 2 and 3
- For J19, CS_EX_IN is ON, MEM_CEN1 and, MEM_CEN2, and MEM_CEN3 are OFF

For the eZ80F91 Module on the eZ80® Development Platform JP3 is OFF.

Procedure

Follow the steps below to setup the UDP Demo application prior to execution:

1. Ensure that the required Demo files are added and integrated to ZTP before proceeding. For details, see Adding and Integrating UDP Demo-Specific Files to ZTP on page 5.
2. Make the connections as shown in Figure 2. Follow the jumper settings provided in Jumper Settings.
3. Connect the 9 V power supply to the eZ80F91 Development Kit.
4. Connect the 5 V power supply to ZPAKII and the 7.5 V power supply to the Ethernet HUB.
5. Launch the HyperTerminal and follow the settings provided in the HyperTerminal Settings.

6. From within the HyperTerminal, press z repeatedly, and then press the reset button on ZPAKII to view the menu to set the ZPAKII IP address.
7. Enter *H* to display help menu, and follow the menu instructions to obtain the IP address for ZPAKII in order to download the Demo file. This ZPAKII IP address must be entered in the ZDS II.
8. Launch ZDS II for eZ80Acclaim!® and open the `ZTPDemo_F91.pro` project file located in the path, `..\ZTP\SamplePrograms\ZTP-Demo`.
9. Open the `main.c` file. Ensure that the `BootInfo` structure contains information that is relevant to your network configuration.
10. Build the `ZTPDemo_F91.pro` project and download the resulting file to the eZ80F91 Module on the eZ80® Development Platform, using ZDS II.
11. Open the file `Clientmain.c` in Microsoft Visual C++ IDE. Ensure that the IP address and port number of the eZ80F91 web server in this file are set as explained Client-Side Implementation on page 4.
12. Compile and build the `Clientmain.c` file into a new project as detailed in the section Compiling and Building the Client-Side Project on page 6.
13. Run both the client- and server-side projects (see Executing the UDP Demo Application).

Executing the UDP Demo Application

Follow the steps below to execute and test the UDP Demo application:

1. Click **GO** icon in the ZDS II toolbar to execute the AcclaimDemo.
2. Press **CTRL+F5** in Microsoft Visual C++ IDE to execute the `Clientmain.c`.

   A DOS window is displayed as the user-interface with the following menu:

   ```
   Menu: :
   1. Read Flash message1
   2. Read Flash message2
   Enter 1 or 2
   ```

3. In the HyperTerminal console, enter `udptest 100` at the prompt to execute the `normal()` thread on the eZ80F91 web server. The argument `100` specifies the size of the UDP packet.
4. In the DOS window, enter either number 1 or 2 after the menu display and press the **Enter** key. The number is sent as a UDP message to the eZ80F91 web server.

   The response (a UDP packet) is parsed by the PC client-side program and is printed in the DOS window.

   `This is message number one` is displayed at the DOS prompt when 1 is entered.

   And,

   `This is message number two` is displayed at the DOS prompt when 2 is entered.
5. To exit from the program, make the HyperTerminal window active, press the **Enter** key, and close all running programs.

Summary

This application note demonstrates the exchange of datagrams between a PC client and the eZ80F91 web server using the UDP layer of ZTP. Compared to TCP, UDP functions are easy to use and provide a faster way of exchanging messages. UDP is beneficial for eZ80F91-based products, provided that all the errors arising in this kind of transaction are taken care of.

The source code for programs provided in this application note for both the client-side and the server-side, can be utilized as templates, on which complex applications can be built. UDP is the underlying protocol for SNMP, TFTP, BOOTP, TIMEP and DNS protocol layers, all of which are supported in ZTP.

References

Further information on UDP, the RFC defining the protocol and details of the eZ80® family of products, ZTP and ZDS II can be found in the references listed below:

- eZ80® CPU User Manual (UM0077)
- eZ80F91 MCU Product Specification (PS0192)
- Zilog Developer Studio II-eZ80Acclaim!® User Manual (UM0144)
- ZPAK II Debug Interface Tool Product User Guide (PUG0015)
- Zilog TCP/IP Stack API Reference Manual (RM0040)
- Zilog TCP/IP Software Suite Programmer's Guide (RM0041)
- Zilog TCP/IP Software Suite Quick Start Guide (QS0049)
- UDP Protocol RFC 768 — The full text of the RFC 768 is available at the URL http://www.ietf.org/rfc/rfc768.txt

Appendix A—Flowcharts

This appendix contains the flowcharts for the UDP application implementation described in this Application Note.

Figure 3 displays the flowchart for the client-side program, `Clientmain.c`.

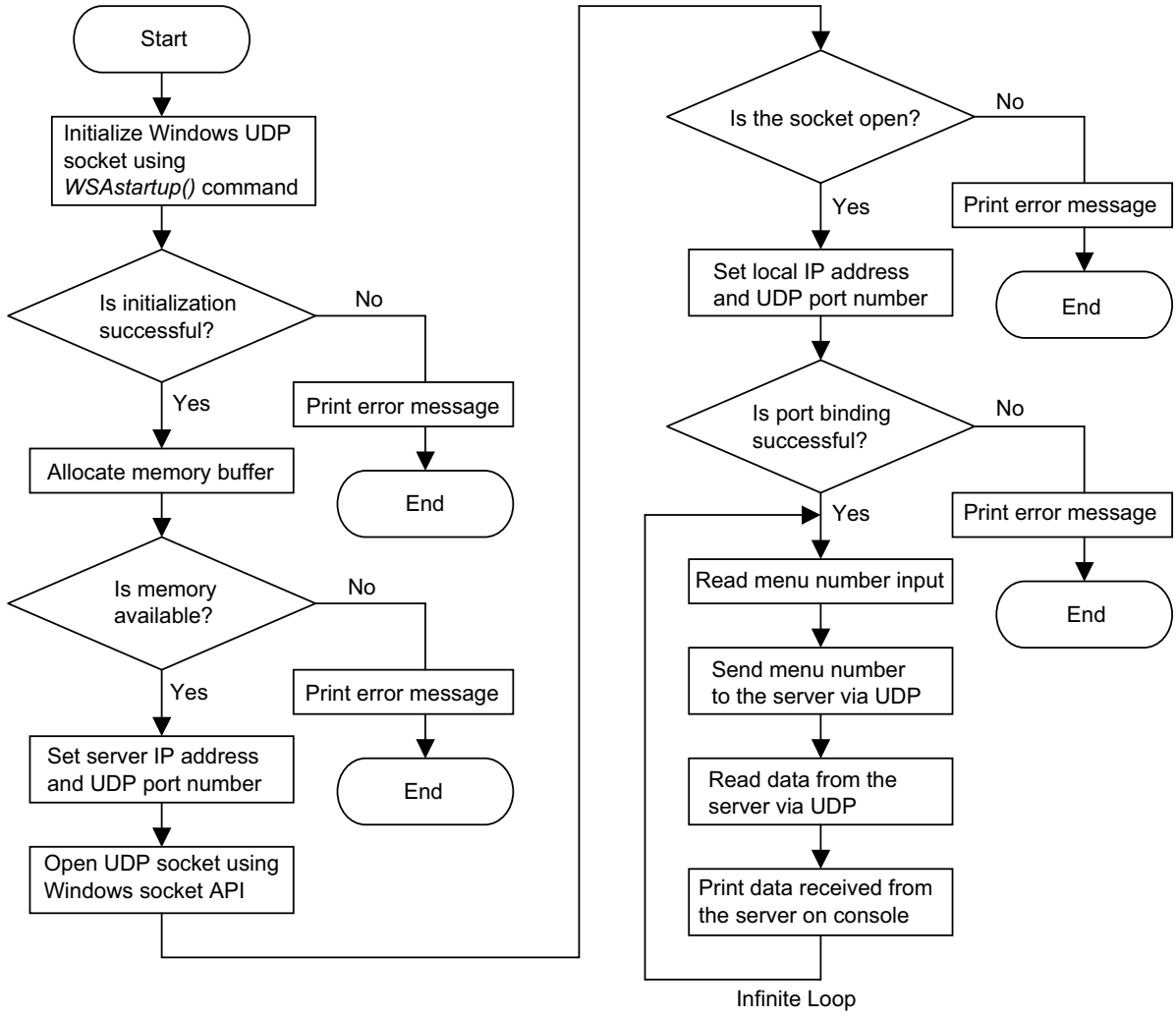

Figure 3. Flowchart for the Client-Side Program

Figure 4 displays the flowchart for the execution of the UDP-related thread, the `normal()` function.

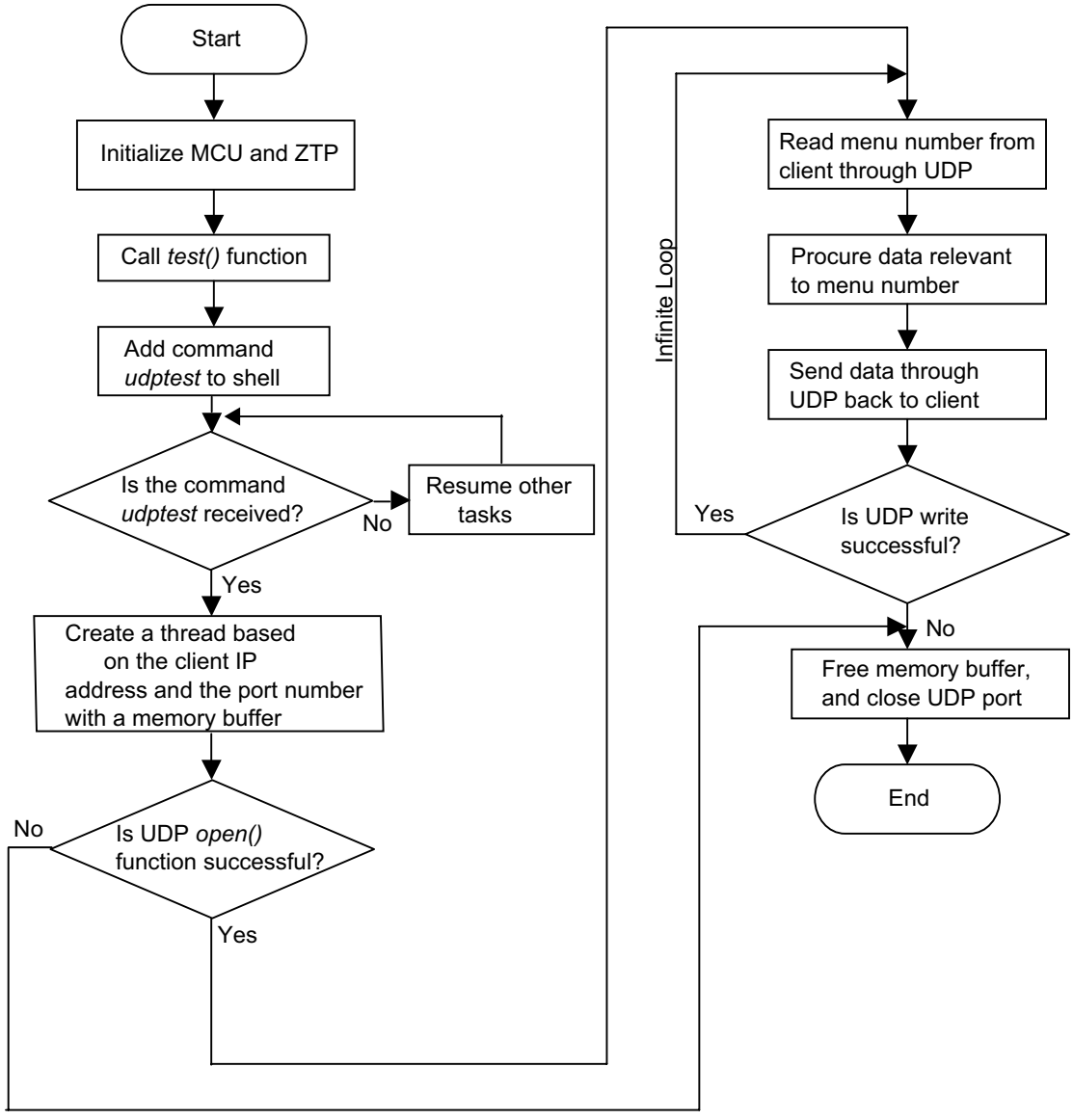

Figure 4. Flowchart for the UDP Thread, the normal() Function

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As used herein

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

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