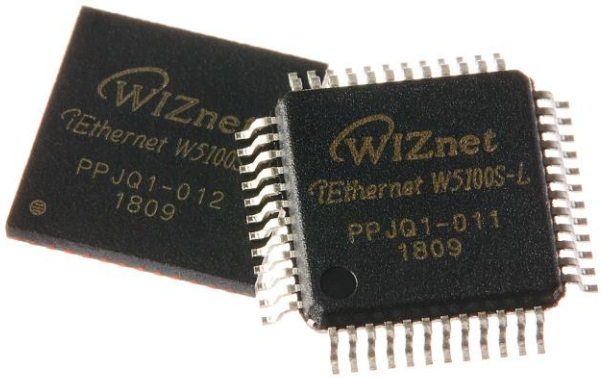
# PPPoE Application Note in MACRAW mode




**Version 1.0.0**



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# Table of Contents

# 1 Introduction

WIZnet TCP/IP devices support PPP/PPPoE protocol implemented in MACRAW mode. PPP protocol is Link-layer protocol to configure point-to-point connection to Network Access Server(NAS) provided by Internet Service Provider(ISP) and to send IP data packet. Typical use of PPP/PPPoE example is ADSL, ADSL is data communication using telephone line and used at a wide range of services.

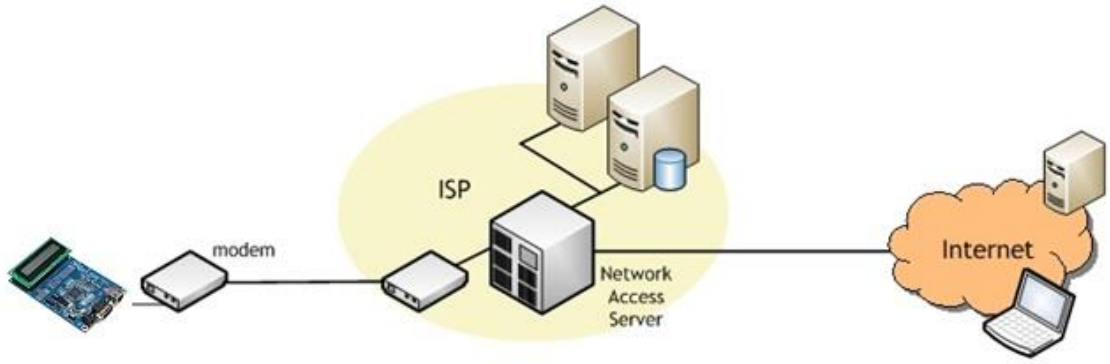


Figure 1. PPPoE (Example: ADSL)

In this application note, we describe structure of PPPoE protocol implemented by **MACRAW** mode firmware and connected to the Internet by using pseudo code.

MACRAW mode is a communication method for user to use an upper protocol flexibly based on Ethernet MAC.

Implemented PPPoE protocol is performing as Figure 2.

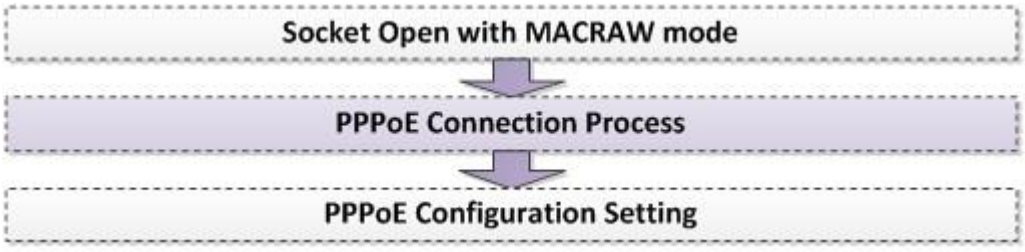


Figure 2. Simple flow of PPPoE with MACRAW mode

First, after open the socket with MACRAW mode, run PPPoE Connection Process. PPPoE Connection Process exchanges messages between terminal and NAS corresponding to each of Discovery, LCP, Authentication(PAP and CHAP) and IPCP protocol, so WIZnet's TCP/IP device could be assigned a IP address from NAS. Finally point-to-point connection has completed.

# 2 Implementation

The exchange of messages of PPPoE Connection Process has shown in Figure 3.

Rx, Tx buffer is the logical memory space for transmitting and receiving protocol data packet, and it is used by declaring array variable in actual implementation.

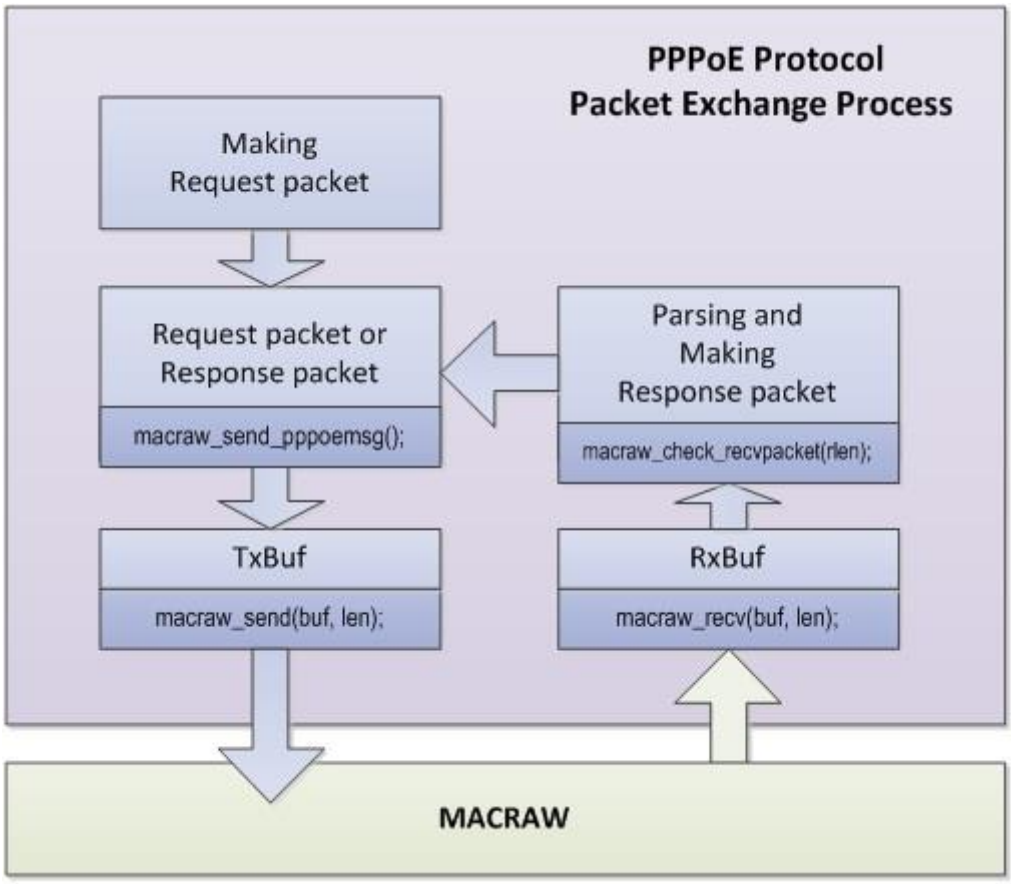


Figure 3. PPPoE Simple Implementation Diagram

Table 1. MACRAW mode PPPoE Functions list

```
// PPPoE Start function
uint8_t ppp_start(uint8_t * pppoe_buf);

// PPPoE Discovery function
void do_discovery(void);

// PPPoE protocol message generate functions
void do_lcp(void);
void do_lcp_echo(void);
uint8_t do_lcp_terminate(void);
void do_pap(void);
void do_pap(void);

// PPPoE protocol message send function
void ppp_send(void);

// PPPoE Packet check and response send function
//Because socket is opened in macraw, parsing first packet and then next time parsing next packet
void ppp_recv( uint16_t received_len );

// Write Server MAC address and session ID
void set_pppinfo(uint8_t * nas_mac, uint8_t * ppp_ip, uint16_t nas_sessionid);

// PPPoE Delay function
void delay_ms(uint32_t time);
```

# 3 Connection Process

PPPoE connection goes through the following processes with MACRAW mode.

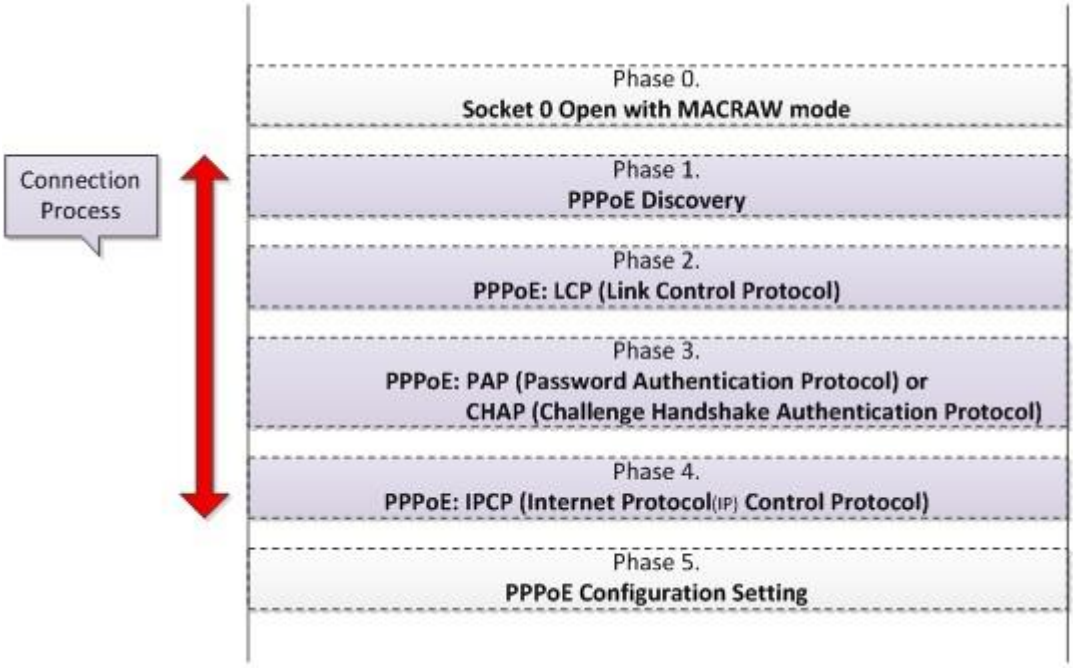


Figure 4. PPPoE Connection Process with MACRAW mode

**Phase 0. MAC**

Performing a basic configuration for PPPoE connection and communication.

**Phase 1. PPPoE Discovery Process**

Performing to connect to the PPPoE Server(NAS).

**Phase 2. PPP LCP Configuration Process**

Determining the basic configuration for PPPoE connection by negotiation with NAS.

**Phase 3. PPP Authentication Process**

Performing user authentication using Password Authentication Protocol(PAP) or Challenge-Handshake Authentication Protocol(CHAP)..

**Phase 4. PPP IPCP Configuration Process**

Obtaining IP, gateway, and DNS address for IP protocol

**Phase 5. PPPoE Configuration Setting Process**

Opening the socket in PPPoE mode to record destination IP, MAC address, session ID in WIZnet's TCP/IP device and setting timeout

## 3.1 Socket 0 Open in MACRAW mode

WIZnet's TCP/IP device needs to set a basic configuration to create PPPoE connection and communication. We use MACRAW mode for PPPoE in this application note, so open socket "0" for MACRAW mode.

Table 2. Socket OPEN with MACRAW mode

```
/* PPPoE Setup */
#define Sn_MR_MACRAW      0x04
sock_num = 0; // The SOCKET number. Only use SOCKET "0".
dummyPort = 0; // The source port for the socket, not used port number.
mflag = 0x40; // MAC filter enable in MACRAW

/* OPEN SOCKET0 with MACRAW mode */
switch(getSn_SR(sock_num)
{
   Case SOCK_CLOSED :
      close(sock_num);
      socket(sock_num, Sn_MR_MACRAW, dummyPort, mFlag);
      break;
   Case SOCK_MACRAW :
      …
      break;
}
```

## 3.2 PPPoE Discovery Process

PPPoE Discovery Process is a procedure that device tries to connect to the PPPoE Server(NAS).

- *Obtaining MAC address of NAS.*
- *Obtaining Session ID from NAS.*

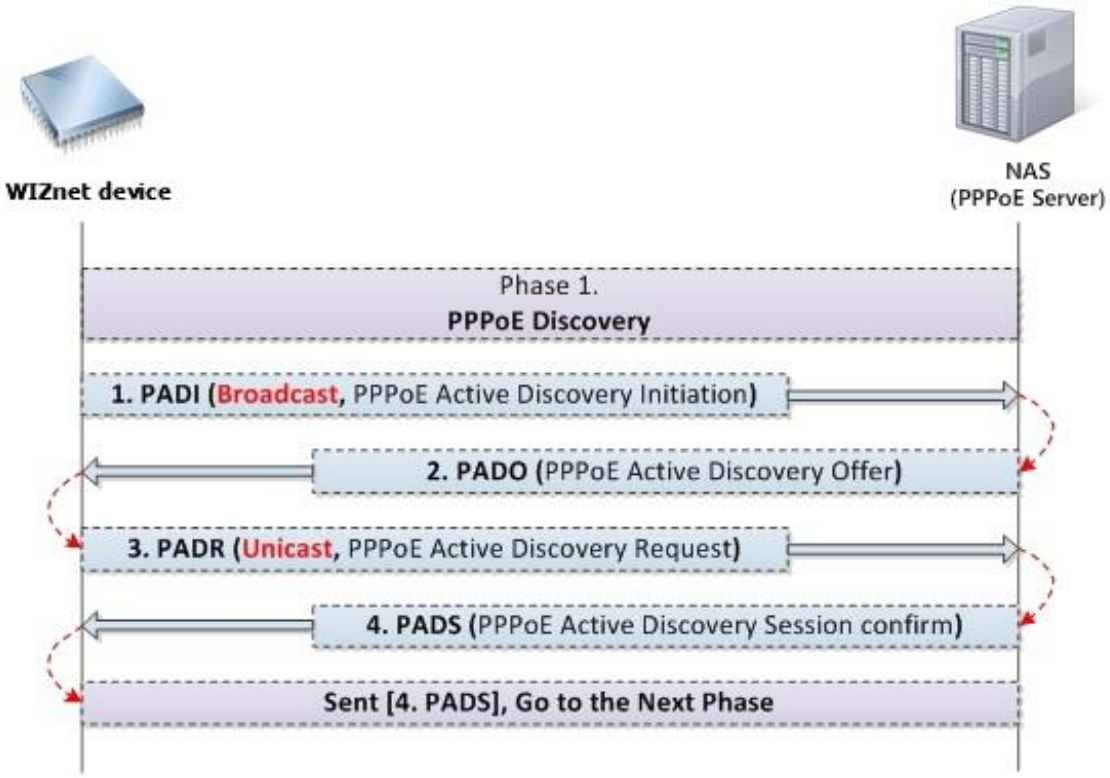


Figure 5. PPPoE Discovery Process

Table 3. PPPoE Discovery

```
/* PPPoE Discovery */
pppoe_state = PPPoE_DISCOVERY;
/* PPPoE Discovery   : ppp_start() */
If((FLAG_DISCOVERY_RCV_PADA) == 0 || (FLAG_DISCOVERY_RCV_PADS) == 0)
{
   do_discovery(); // Send PADI massage using broadcast
   pppoe_retry_send_count++;
}
pppoe_recv_count = 0;
while( ! FLAG_DISCOVERY_RCV_PADS && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )// Not
receiving PADS and time out
{
    delay_ms(20); // Delay 20 ms to give margin to receive response packet
```

```
    pppoe_recv_count ++; // Count ppp_recv call for time out
    received len = getSn_RX_RSR(sock_num) // Received packet length
  if( received_len > 0 ) // If packet received
  {
     ppp_recv(received_len);// Receive packet and Parse process
     if( FLAG_DISCOVERY_RCV_PADS )
       pppoe_state = PPPoE_LCP; // Go to the next phase: PPPoE_LCP
  }
}

/* PPPoE Discovery :   ppp_recv(received_len) */
…
Case PPPoE_DISCOVERY :
  If( PPPoE_PADO ) // PADO massage received
  {
     while( taglen ) // If tag length > 0
     {
        switch( tagname ) // Process Tags and making PADR massage
        {
           case SERVICE_NAME :
           case HOST_UNIQ :
           case AC_NAME:
           case AC_COOKIE :
              // Making PADR massage
              break;
        }
        taglen =- ppp_tag_len; // Length of all tags - length of each tag
     }
     ppp_send(); // Send PADR massage using unicast
  }
  else if( PPPoE_PADS ) // PADS massage received
  {
     // Session ID is used for whole connection process after PPPoE discovery process.
     NAS_sessionid = received NAS session ID; // Save Session ID from NAS
     pppoe_control_flag = pppoe_control_flag | FLAG_DISCOVERY_RCV_PADS;// Received PADS indicate
     flag
  }
Break;…
```

## 3.3 PPP LCP Configuration Process

PPP LCP Configuration Process is a procedure for determining the basic configuration by negotiation with NAS for PPPoE connection.

PPP LCP configuration process requests(Config-Request) and acknowledges(Config-ACK) to NAS mutually using LCP option lists as follows and should be designed to use same Magic number in each packet of request and acknowledgement.

- *MRU (Maximum Receive Unit)*
- *Authentication Protocol (PAP, CHAP and etc.)*

<Notice>

Provided **ppp_recv(received_len)** function of example firmware source code which is parsing received packet is not implemented with all option but with minimum option for fundamental PPPoE connection.

If user wants additional option, implement the option by referring to option lists of protocol defined in RFC. Part of this is displayed as 'notice' in example code.

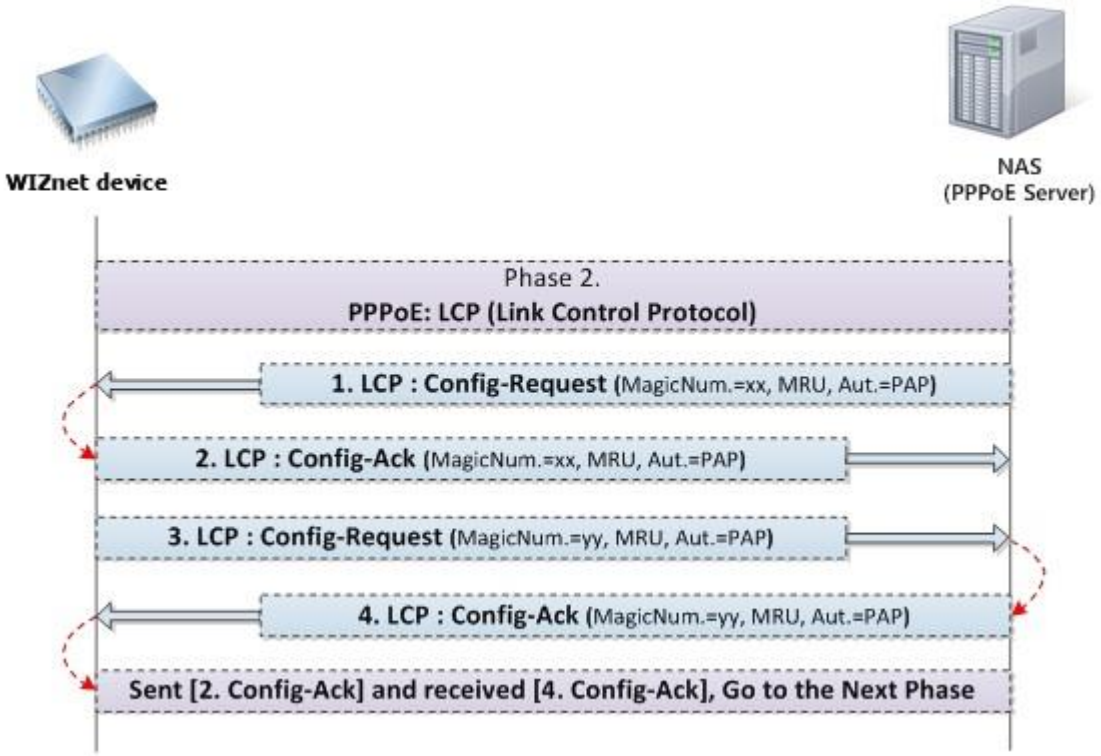


Figure 6. PPP LCP Configuration Process

Table 4. PPP LCP Configuration

```
/* PPP LCP Configuration   : ppp_start() */

do_lcp_echo();// Send LCP Echo-Request
pppoe_retry_send_count++;// Count ppp_recv call for time out

pppoe_recv_count = 0;
while( ! FLAG_LCP_CR_RCV && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )// Not receiving
Configuration Request and time out
{
   delay_ms(20); // Delay 20 ms to give margin to receive response packet
   pppoe_recv_count ++;// Count ppp_recv call for time out
   received_len = getSn_RX_RSR(sock_num);
   if( received_len > 0 )
   {
      ppp_recv(received_len); // Receive packet and Parse process
      if (FLAG_LCP_CR_RCV ) pppoe_retry_send_count = 0;
   }
}

if((pppoe_control_flag & FLAG_LCP_CR_RCV) == FLAG_LCP_CR_RCV)
{
   do_lcp();// Send LCP Configuration-Request
   pppoe_retry_send_count++;

   pppoe_recv_count = 0;
   while( ! FLAG_LCP_CR_SNT && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )
   {
      delay_ms(20); // Delay 20 ms to give margin to receive response packet
      pppoe_recv_count++;// Count ppp_recv call for time out
      received_len = getSn_RX_RSR(sock_num);
      if( received_len > 0 )
      {
         ppp_recv(received_len); // Receive packet and Parse process
         if( FLAG_LCP_CR_SNT )
         {

         // Authentication protocol : PAP, Go to the next phase: PPPoE_PAP
```

```
        if( auth_protocol == PPPoE_PAP ) pppoe_state = PPPoE_PAP;
        // Authentication protocol : CHAP, Go to the next phase: PPPoE_CHAP
        else if( auth_protocol == PPPoE_CHAP ) pppoe_state = PPPoE_CHAP;
        // Unknown Authentication protocol, Go to the failed state: PPPoE_FAILED
        else pppoe_state = PPPoE_FAILED;
    }
  }
}
/* PPP LCP Configuration : ppp_recv(received_len) */
…
Case PPPoE_SESSION :
  if( PPPoE_LCP )
    Switch( ppp_code )
    {
      Case CONFIG_REQ :
        getlen = all option length;
        While( getlen )
        {
          opt_code = option code;
          opt_len = option length;
          Switch( opt_code )
          {
            Case LCP_MRU :
            Case LCP_AUTH :
            Case LCP_MAGICNUM :
              // Parsing and making Config-Ack massage
              break;
            Default :
              // Making Config-Reject massage
              // and rej_idx += opt_len;
              break;
          }
          getlen -= opt_len;
        }
        // Send Response message for Request message from NAS
        If( rjt_idx ) // if any option is rejected, send reject message and then wait Config-Request
        {
          // Making Config-Reject massage and send
```

```
            ppp_send();
          }
          else // Send Config-Ack, lcp_cr_rcv flag set
          {
            // Making Config-Ack massage and send
            ppp_send();
          }
          Break;

        Case CONFIG_ACK : // ack, then lcp_cr_sent flag set
          FLAG_LCP_CR_SNT = 1; // Set flag
          Break;

        /* Notice :   This part is not implemented. */
        /* If necessary, please implement more for reply for request from NAS. */
        /*
        case CONFIG_REJ : //reject
          break;
        case ECHO_REQ : // Echo-Request
          break;
        */
        Default : break;
      }
    Break;
Break;
…
```

## 3.4 PPP Authentication Process

PPP authentication process is the procedure to perform user authentication for PPPoE connection. The method of user authentication is determined by process of LCP Configuration Protocol at chapter 2.4. This example code supports PAP and CHAP as Authentication Protocol and if user wants to design and insert the additional method for user authentication.

### 3.4.1 PAP (Password Authentication Protocol)

PAP is simple user authentication that user sends ID and password to NAS and then NAS checks them and sends ACK(valid user)/NAK(invalid user) to user. If user receives ACK, authentication is completed.

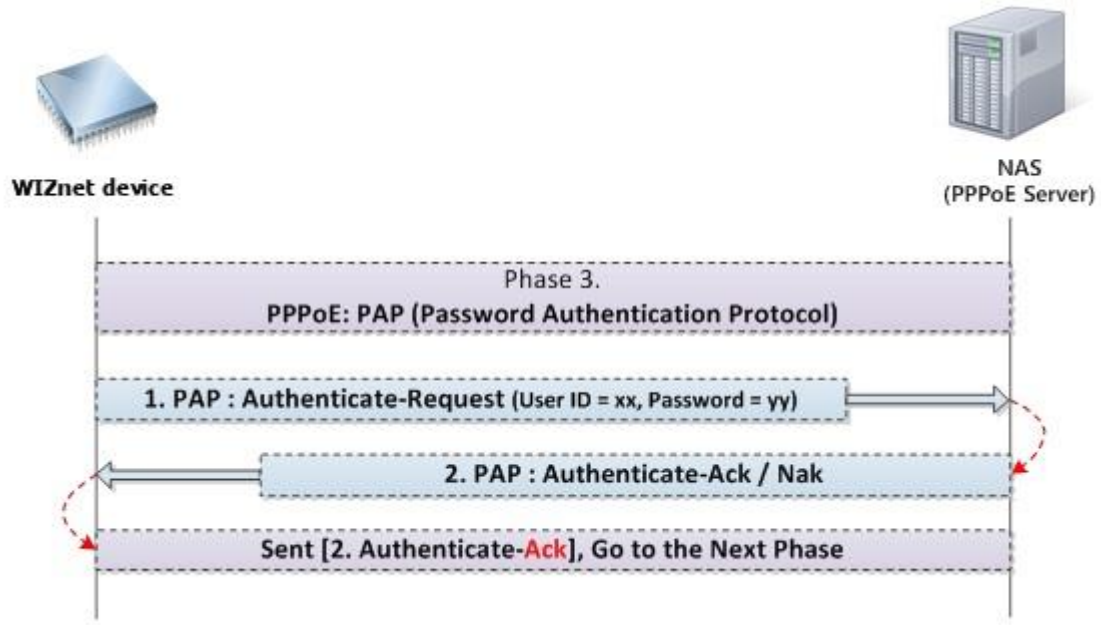


Figure 7. PAP Authentication Process

Table 5. PAP Authentication

```
/* PPP PAP Authentication */
/* PPP PAP Authentication : ppp_start() */
do_pap();// Send PAP Authentication-Request
pppoe_retry_send_count++;

pppoe_recv_count = 0;
While( ! FLAG_PAP_ACK_RCV && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )// Not receiving
Authenticate Ack and time out
```

```
{
   delay_ms(20); // Delay 20 ms to give margin to receive response packet
   pppoe_recv_count ++;// Count ppp_recv call for time out

   received len = getSn_RX_RSR(sock_num) // Received packet length
   if( received_len > 0 ) // If packet received
   {
      ppp_recv(received_len); // Receive packet and Parse process
      if( FLAG_PAP_ACK_RCV ) pppoe_state = PPPoE_IPCP; // Go to the next phase: PPPoE_IPCP
   }
}

/* PPP PAP Authentication : ppp_recv(received_len) */
…
Case PPPoE_SESSION :
   If( PPPoE_PAP )
   {
      If( codename == CONFIG_ACK ) FLAG_PAP_ACK_RCV = 1; // Set PAP Ack receive flag
   }
   Break;
…
```

### 3.4.2 CHAP (Challenge-Handshake Authentication Protocol)

CHAP, another authentication protocol, the device requires to send an encrypted password to NAS, so it has more security than PAP. The basic procedure for CHAP authentication is like 3-way handshaking as shown in Figure 7. CHAP Authentication Process.

Steps:

1. The NAS(PPPoE Server) sends CHAP-Challenge packet containing Challenge Value(CV) which is random value to terminal.
2. The terminal which receives CHAP-Challenge packet makes Hashed Value(HV) with Message Digest 5(MD5) using CV, own password, and ID and then sends CHAP-Response packet with HV to NAS..
3. The NAS checks the received HV and compares it to own HV of the user's password, sent challenge, and session ID.
4. If the comparison is successful, the user acquires access to the server. The reply packet from the server to the user indicating success or failure of login also contains the server's response to the user challenge.

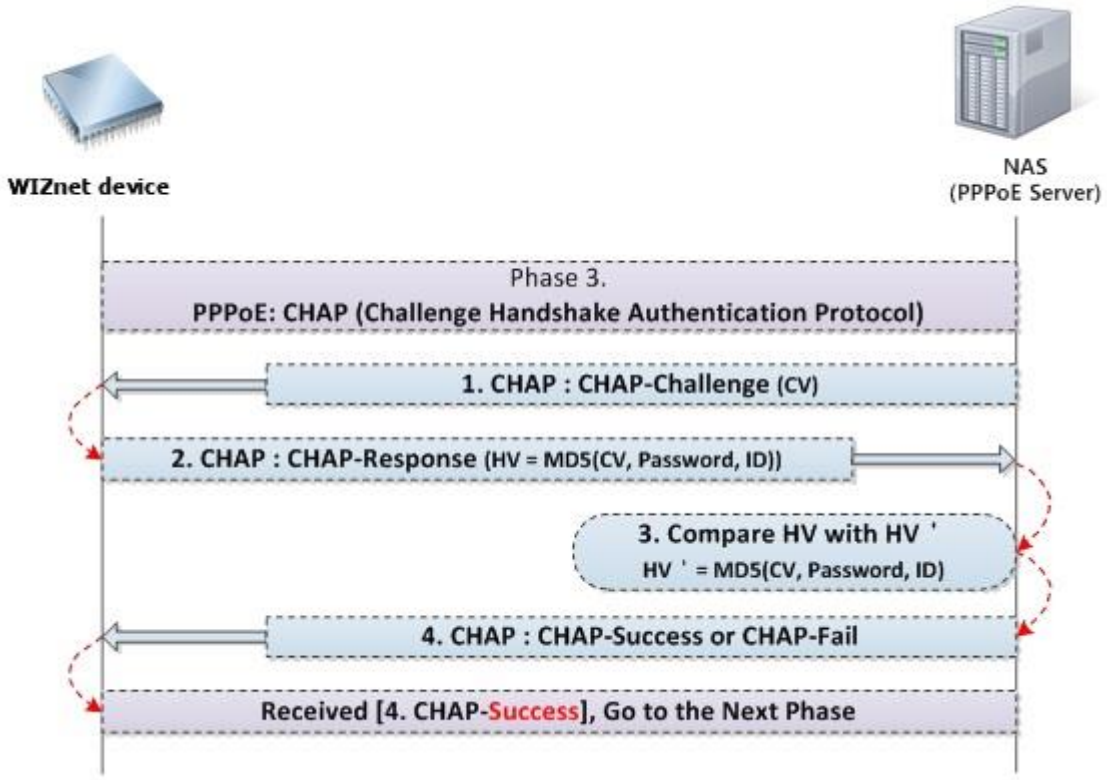


Figure 8. CHAP Authentication Process

Table 6. CHAP Authentication

```
/* PPP CHAP Authentication */
/* PPP CHAP Authentication : ppp_start() */
pppoe_recv_count = 0;
While( ! FLAG_CHAP_SUC_RCV && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT ) )// Not receiving CHAP-Success and time out
{
  delay_ms(20); // Delay 20 ms to give margin to receive response packet
  pppoe_recv_count ++;// Count ppp_recv call for time out
  received len = getSn_RX_RSR(sock_num) // Received packet length
  if( received_len > 0 ) // If packet received
  {
    ppp_recv(received_len); // Receive packet and Parse process
    if( FLAG_CHAP_SUC_RCV ) pppoe_state = PPPoE_IPCP; // Go to the next phase: PPPoE_IPCP
  }
}

/* PPP CHAP Authentication : ppp_recv(received_len) */
…
Case PPPoE_SESSION :
  If( PPPoE_CHAP )
  {
    Switch( chap_algorithm )
    {
      Case MD5 : // 0x05, using MD5 algorithm
        Switch( codename )
        {
          Case 0x01 : // CHAP-Challenge
            // MD5 Calculation CV and send CHAP-Response to NAS
            ppp_send();
            break;
          Case 0x03 : // CHAP-Success
            FLAG_CHAP_SUC_RCV = 1;
            break;
          Case 0x04 : // CHAP-Failed
          Default : break;
        }
        break;
```

```
        /* Notice :   This part is not implemented. */
        /* If necessary, please implement more for the other CHAP algorithm */
        /*
        Case MS_CHAP : // 0x80
        Case MS_CHAP_V2 // 0x81
           break;
        */
        Default : break;
     }
  }
  Break;
…
```

## 3.5 PPP IPCP Configuration Process

PPP IPCP Configuration Process obtains IP, gateway, and DNS address for IP protocol.

<Notice>

Provided **ppp_recv(received_len)** function of example firmware source code which is parsing received packet is not implemented with all option but the least option for fundamental PPPoE connection.

If user wants additional option, implement option by referring to option lists of protocol defined in RFC. Part of this is displayed as 'notice' in example code.

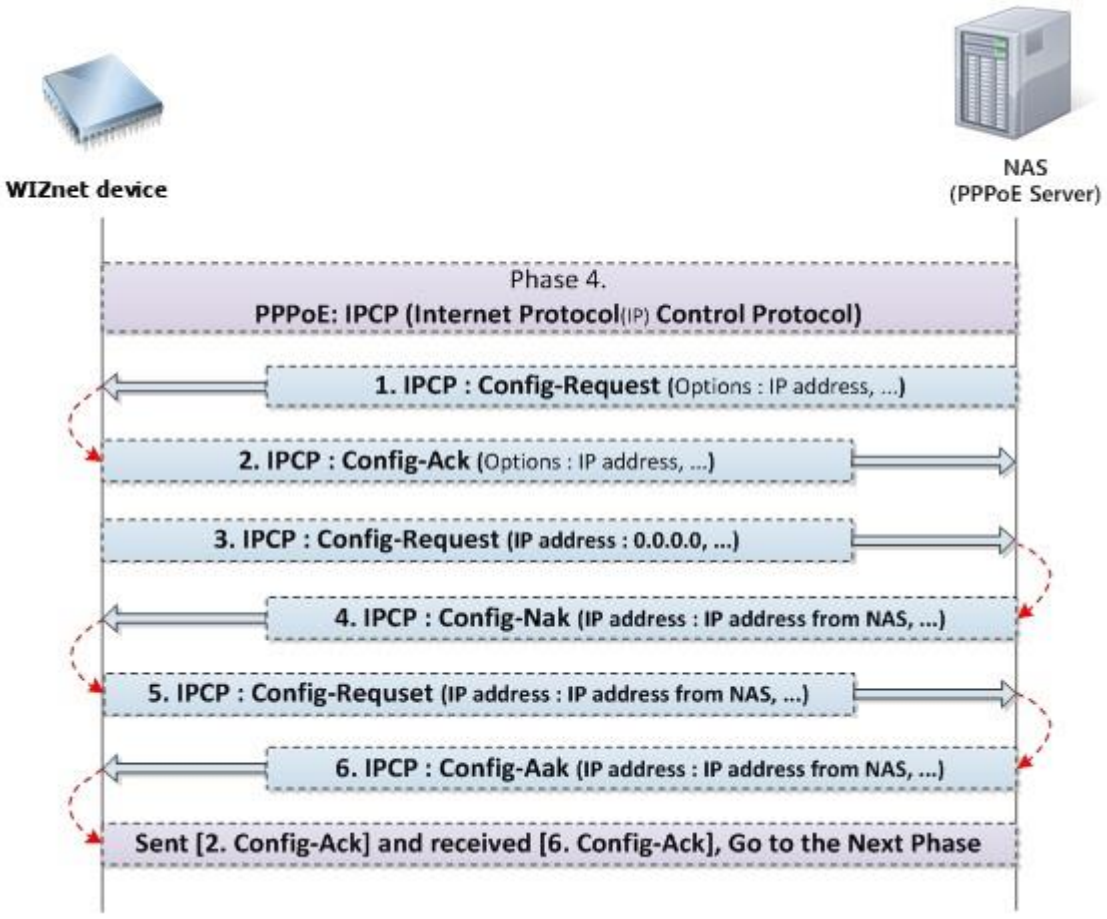


Figure 9. PPP IPCP Configuration Process

Table 7. PPP IPCP Configuration

```
/* PPP IPCP Configuration */
/* PPP IPCP Configuration : ppp_start() */
pppoe_recv_count = 0;
While( ! FLAG_IPCP_CR_RCV && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )
{
   delay_ms(20); // Delay 20 ms to give margin to receive response packet
   pppoe_recv_count ++;// Count ppp_recv call for time out

   received len = getSn_RX_RSR(sock_num) // Received packet length
   if( received_len > 0 ) // If packet received
   {
      ppp_recv(received_len); // Receive packet and Parse process
   }
}
if( FLAG_IPCP_CR_RCV )
{
   do_ipcp();
   pppoe_retry_send_count++;

   pppoe_recv_count = 0;
   While( ! FLAG_IPCP_CR_SNT && pppoe_recv_count < PPP_MAX_RETRYRECV_COUNT )
   {
      delay_ms(20); // Delay 20 ms to give margin to receive response packet
      pppoe_recv_count ++;// Count ppp_recv call for time out
       received len = getSn_RX_RSR(sock_num) // Received packet length
      if( received_len > 0 ) // If packet received
      {
         ppp_recv(received_len); // Receive packet and Parse process
         if ( FLAG_IPCP_CR_SNT )
         {
            // PPPoE Configuration setting
            set_pppinfo(NAS_mac, pppoe_ip, NAS_sessionid);
            // Return PPPoE Connection success
            ret = PPP_SUCCESS;
         }
      }
}
```

```
/* PPP IPCP Configuration : ppp_recv(received_len) */
…
Case PPPoE_SESSION :
  If( PPPoE_IPCP )
  {
    Switch( codename )
    {
      Case CONFIG_REQ :
      Case CONFIG_NAK :
        getlen = all option length;
        While( getlen )
        {
          opt_code = option code;
          opt_len = option length;
          Switch( opt_code )
          {
            Case 0x02 : // IP compression
            Case 0x03 : // IP address
              // Parsing and making Config-Ack massage
              // Save assigned IP address
              break;
            /* Notice :   This part is not fully implemented. */
            /* If necessary, please implement more for DNS or etc.*/
            default :
              // Making Config-Reject massage
              // and rej_idx += opt_len;
              break;
          }
          getlen -= opt_len;
        }
        // Send Response message for Request message from NAS
        If( rjt_idx ) // if any option is rejected, send reject message and then wait Config-Request
        {
          // Making Config-Reject massage and send
          ppp_send();
        }
        else // Send Config-Ack, lcp_cr_rcv flag set
```

```
            {
               // Making Config-Ack massage and send
               ppp_send();
               FLAG_IPCP_NAK_RCV = 1;
            }
            break;
         Case CONFIG_ACK : // Ack, then ipcp_cr_snt flag set
            if( flag_ipcp_nak_rcv ) FLAG_IPCP_CR_SNT = 1;
            break;
      }
   }
   Break;
…
```

## 3.6 PPPoE Configuration Setting Process

Open socket number 0 in MACRAW mode for PPPoE connection and write destination IP, MAC address, session ID received from NAS on WIZnet chip. Then, to use socket number 0 as PPPoE, set MR(Mode register) register as PPPoE after then user can use socket as PPPoE.

The terminal sends LCP Echo Request to NAS frequently as specified timer value. At this time, the period timer is set by PTIMER register.

Table 8. PPPoE Configuration Setting

```
/* PPPoE Configuration Setting */
#define PTIMER              (COMMON_BASE + 0x0028)
#define Sn_MR_PPPOE    0x04
#define Sn_CR_OPEN     0x01

i = 0; // index for 'for' statement

/* Set PPPoE bit in MR(Common Mode Register) : Enable Socket 0 PPPoE */
IINCHIP_WRITE(MR,IINCHIP_READ(MR) | MR_PPPOE);

/* Set PPPoE Network information */
for (i = 0; i < 6; i++) IINCHIP_WRITE((Sn_DHAR0(0)+i), mac[i]); // NAS MAC address
for (i = 0; i < 4; i++) IINCHIP_WRITE((Sn_DIPR0(0)+i), ip[i]); // Assigned IP address
IINCHIP_WRITE((Sn_DPORT0(0)), (uint8)(sessionid >> 8)); // Session ID
IINCHIP_WRITE((Sn_DPORT0(0)+1), (uint8)sessionid);
setSn_IR(0, getSn_IR(0));

/* Set PPPoE Timer */
IINCHIP_WRITE(PTIMER,200); // 5 Sec timeout
/* Open Socket in PPPoE mode */
IINCHIP_WRITE(Sn_MR(0),Sn_MR_PPPOE);
IINCHIP_WRITE(Sn_CR(0),Sn_CR_OPEN);
while( IINCHIP_READ(Sn_CR(0)) );
wait_1us(1);
```

# 4 Demonstration

The following are processes of acquisition of IP address from NAS with PPPoE protocol in MACRAW mode and with W5100S. NAS is Windows Server 2000, and authentication protocol is PAP. IP pool is from 192.168.200.42. All process is completed successfully, and then PPPoE Configuration Setting Process(Chapter 3.6) is running and the terminal sends LCP Echo Request to the NAS whenever timer value is same as PTIMER value in order to keep the connection.

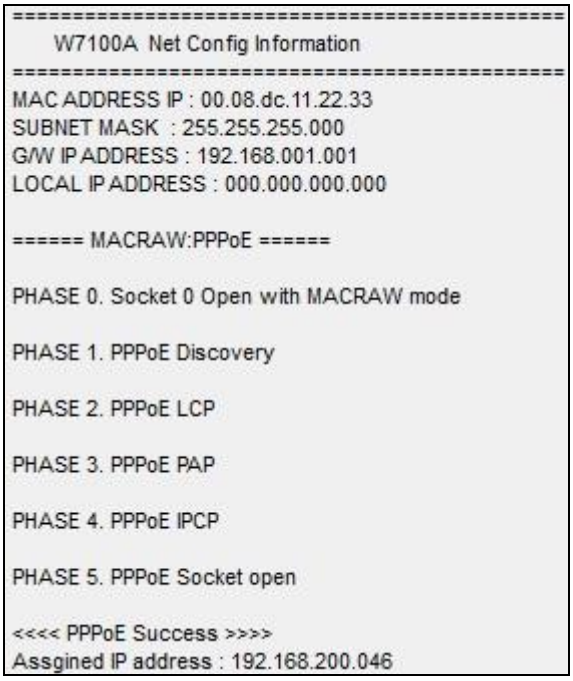


Figure 10. Serial Terminal capture of PPPoE Demonstration

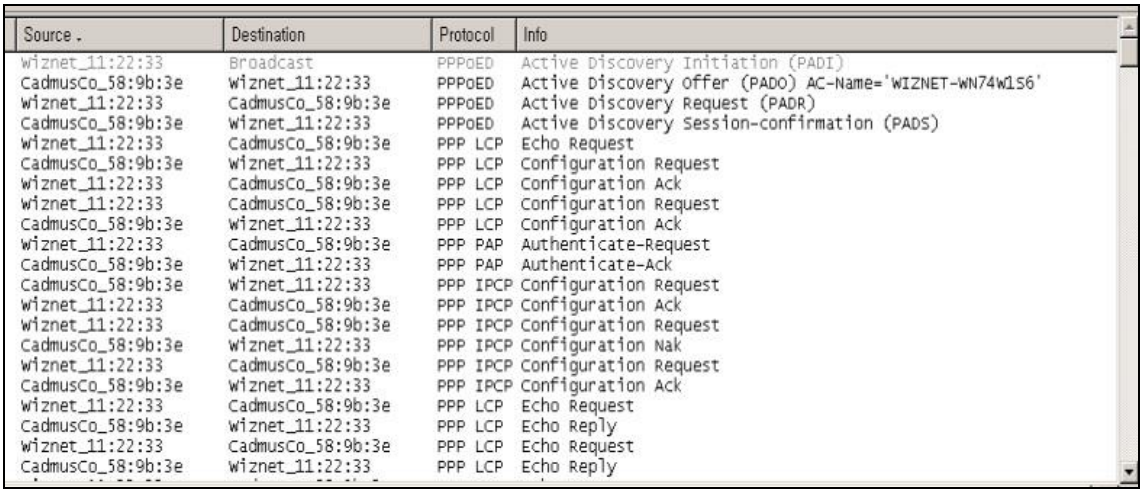


Figure 11. PPPoE Connection Process - Packet Capture

## Document History Information

| Version | Date | Descriptions |
|---|---|---|
| Ver. 1.0.0 | 30MAR2018 | Release |
| | | |




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