(54)　　　　　　　　　　　　/

(Time Varying)　　　,

/

.

(PLC)　　　　　　　(DMT)

,

,　　　　　　　　　　　　　　　　　　(SNR)

1　　　　　1

.

4

1   (ADSL)   (ATU- C)   (ATU- R)
                                                                    ,

2a   2b   1   /
                                                               ,

3   /
                                                       ,

4
                                   /   .

<   >

50: /   , 52:QAM   ,

54:              , 56:   ,

58:                , 60:   ,

62:                , 64:   ,

66:QAM   , 68: /   .

                                            /
                                      ,   (Tone   Subcarrier   Su
bchannel)   ,
                              (Time Varying)   ,
                                                      /
                  .

                        ,
                                    (Downstream)   7 Mbps   (Upstream)   640
Kbps   (Asymmetric Digital Subscriber Line; ADSL)
                        .

,   56 Kbps   (PSTN)   , 128 Kbps
            (ISDN)
              ,
                                                                        .

,   ,   (Duplex)
,   POTS(Plain Old Telephone Service)
          (Frequency Division Multiplexing; FDM)   ,
                                                                                              (Discrete Multi Tone
; DMT)   .

                              (DMT)   4 KHz   256   ,
                                          (Quadrature Amplitude Modulation; QAM)
(Quadrature Phase Shift Keying; QPSK)   ,
                      (QAM)   .

          ,   (QAM)   2   (Baseband)
            I(In- Phase)   Q(Quadrature- Phase)
                              ,   .

      1   (ADSL)   (ATU- C)   (ATU- R)
                                                                                        .

      1   ,
                        (ADSL Terminal Unit- Central Office; ATU- C)   ,   (ADSL Terminal Unit-
Remote; ATU- C)   (ATU- R)   ,   (ATU- C)
    (ATU- R)   (ADSL)   ,
            (ATU- C)   (ATU- R)
,   /   (10) (30)   (20) (40)
        .

            ,   (ATU- C)   (10)   (ATU- R)   (30)
    (DMT)   (IFFT)
                    ,   (ATU- R)   (40)   (20)   (20)
                                                            (FFT)   .

      ,   (ATU- C)   (10)
    (20)   ,   (ATU- R)   (30)   (40)   (Handshaking)
            (Synchronization)   (Equalizer Training)   ,
                                  ,   (Initialization)   .

                                          (ATU- C)   (ATU- R)
                                                                              (Throughput)   (
Reliability)   ,   /   (ATU- C)
    (ATU- R)   (Activation And Acknowledgement)
        ,   (Automatic Gain Control; AGC)   ,   /
                              ,   ,
          4   ,   ,   (Signal To Noise Ratio;
SNR)   ,

(Symbol)   (Bit)   (Performance Margin)
.

2a   2b   1   /
.

2a   2b   ,   (ATU- C)   C- QUIET2   (ATU- R)
    R- QUIET2   ,   (ATU- C)
        512   64   C- PILOT   ,
                        (ATU- R)   C- PILOT
.

,   (ATU- C)   C- REVERB   (ATU- R)   R- REVER
B   (AGC)   ,   ,   ,
C- REVERB   R- REVERB   (Pseudo Random Sequence; PRS)   ,
C- REVERB   d(n)   d(n) = 1(n= 1   9), d(n) = d(n- 4) + d(n- 9) (n= 10   511)
.

,   2   d(n)   256   ,   1
        = d(1)   d(2),   2   = d(3)   d(4), ... ,   256   = d(511)   d(51
2)   4-   (4- QAM)   .   ,
    (PRS)   511   d(512)   d(1)   ,
    64   " 0,0"   , I   Q   (Constellation P
oint)   1   (+ ,+)   (Overwrite)   .

            (ATU- R)   R- REVERB   2   d
(n)   d(n) = 1(n= 1   6), d(n) = d(n- 5) + d(n- 9) (n= 10   63)   (PRS)
.

,   (ATU- C)   C- SEGUE   (ATU- R)   R- SEGUE
        REVERB   180   ,
        (MEDLEY   , RATES   )
.

,   (ATU- C)   C- RATES1/C- CRC1/C- MSG1/C- CRC2
    (ATU- C)   R- RATES1/R- CRC1/R- MSG1/R- CRC2   (DMT)   1   (Symbol)
1   ,   2
    " 0"   REVERB   , " 1"   SEGUE   , CRC   EXG
.

, (ATU- R) C- MEDLEY (ATU- C) R- MEDLEY
(SNR)
(PRS) , 2 d(n) 256
, REVERB 1
.

, C- MEDLEY R- MEDLEY 1 = d(1) d(2), 2
= d(3) d(4), ... , 256 = d(511) d(1) , 1
= d(2) d(3), 2 = d(4) d(5), ... , 256 = d(1) d(2) 1
, 512 1 = d(1) d(2), 2 = d(3) d(
4), ... , 256 = d(511) d(1) . MEDLEY
(Inter- Symbol Interference; ISI) ,
(SNR) .

, (ATU- C) C- RATES- RA/C- CRC- RA1/C- MSG- RA/C- CRC-
RA2 , C- MSG2/C- CRC3/C- RATES2/C- CRC4 , C- B& G/C- CRC5 , (ATU- R)
R- RATES- RA/R- CRC- RA1/R- MSG- RA/R- CRC- RA2 , R- MSG2/C- CRC3/R- RATES2/C-
CRC4 , R- B& G/R- CRC5 (DMT) 1 8 ,
4 4- .

, 2a
2b (ATU- C) (ATU- R)
, (SHOWTIME)
.

, ITU- T G.992.2 - Splitterless Asymmetric D
igital Subscriber Line(ADSL) 11 ( ) .

, , , , ,
(PLC) ,
/
(TDD/TDMA) .

, ,
.

, (ADSL) (FDN)
, /
,
.

2002- 0035956

,

(SNR)   ,   ,
                                                                                          ,

,   ,
                    .

,   (Bridge Tap)
                                        (Frequency Selective Fading)   ,
                    (Time Varying)   ,
        (ADSL)
                                                                              .

,   ,
                                                                      ,
                                                              /
                    .

                                ,   (Clock Recovery)
                                        /
        .

                                                                                                        ,
                1   1   /
                                                              .

                                                                                  /
                                                              .

                                ,
                (PLC)   (DMT)
                    ,
                                                                                                  ,
        (SNR)
                1   1   /
                                                      .

,   .

,   3   /
                                                          .

– 6 –

3   (M
U) ,   (SU)
        .

          ,   (MU)   (SU)
                    ,   (MU)   (SU)
          .

          ,   (MU)   /   (50)   , QAM   (52),   (54),
    (56; IFFT),   (58)   ,   (62)   ,   (64; FFT), QA
M   (66)   ,   /   (68)   ,
    (60)   ,   (70)   .

          ,   (SU)   (80)   ,   (90)   ,   (100)   ,
          (80)   (MU)   ,   (90)
          (MU)   ,   (80)   (90)
                    .

          (MU)   ,   /   (50)   (MU)
                                ,   QAM   (52)
                    .

          ,   /   (50)   (sec)   b $_{total}$ /T (bits)
              , b$_{total}$ (bits)   (DMT)   ,   T   .

          ,   (54)   (70)   NOSIG, TONES, TRAIN, NTRAIN, M
EASURE, EXG, CRC   ,   (56)
                              (54)
    ,   QAM   (52)   (Steady State   Show Time)
        .

          ,   (56)   i   b $_{i}$ (bits)   N
    b$_{total}$ (bits)   ,   b$_{total}$ (bits)   N $_{s}$ (Tim
e Domain)   ,   N $_{s}$ 2N   .

          ,   (58)   (56)
                                                                                                  ,   (6
0)   (58)   (62)
                    (SU)   .

          (MU)   ,   (62)   (60)
          (SU)
                    .

          ,   (64)   (62)
                                                                                                  ,   i
b$_{i}$ (bits)   .

, QAM (66) (64)

, / (68) QAM

(66) .

, (70) (54) NOSIG, TONES, TRAIN,

NTRAIN, MEASURE, EXG, CRC ,

QAM (52) (56)

.

, (70) ,

3 5

.

, (70) (MU) (S

U) , (DMT) 1 1

.

, (70)

/ (Time Varying)

,

.

, (70) ,

(Digital Signal Processor; DSP)

(70) .

, (SU) (80) (MU)

(100) NOSIG, TONES, TRAIN, NTRAIN, MEASURE, EXG, CRC

(MU) .

, (SU) (90) (MU)

, (MU)

.

, 4 .

, (MU) (SU)

, (MU) (SU)

.

, (MU) , M- NOSIG, M- TONES, M- TRAIN, M- NTRAI

N, M- MEASURE, M- EXG, M- CRC , (SU) S-

NOSIG, S- TONES, S- TRAIN, S- NTRAIN, S- MEASURE, S- EXG, S- CRC

(MU) .

, (MU) M- NOSIG (SU) S- NOSIG

(No Signal) , .

, (MU) (SU)

, NOSIG

.

, (SU) S- TONES , (MU)

(70) S- TONES , (54)

M- TONES . , M- TONES (DMT) (T_m1)

(SU) (90) (Tone Detection) 20

40 DMT .

, M- TONES 3 5

, ,

.

, (MU) (70) M- TONES , M-

TRAIN1 M- NTRAIN1 M- MEASURE , (SU)

(S- NOSIG1) .

, TRAIN (AGC) , , ,

, (PRS) d(n) (n= 1 512)

2 , d(n) = 1(n= 1 9), d(n) = d(n) + d(n- 9) (n= 10 511)

.

, M- TRAIN1 1 = d(1) d(2), 2 = (d(3) d(4), ... , 256

= d(511) d(512) 4- (4- QAM) (,

(PRS) 511 , d(512) d(1)),

(+ ,+) ,

. , M- TRAIN DMT (T_m2) (SU) (90)

, , , 1000

DMT .

, NTRAIN (Negative) TRAIN , TRAIN 180

, DMT (T_m

3) 10 20 DMT . , (+ ,+)

.

, MEASURE (MU) (SU)

(SNR) (PRS) ,

TRAIN 1 .

, MEASURE 1 = d(1) d(2), 2 = d(3) d(4), ... ,

256 = d(511) d(1) , 1 = d(2) d(3), 2

= d(4) d(5), ... , 256 = d(1) d(2) 1 ,

512 1 = d(1) d(2), 2 = d(3) d(4), ... , 256

= d(511) d(1) . (+ ,+)

.

MESURE (ISI) ,
(SNR)
(Bit Allocation) . , MEASURE DMT (T_m4)
(SNR) , 1000 2000 DMT .

M- TONES , M- TRAIN1 , M- NTRAIN1 , M- MEASURE ,
(SU) (100) M- TRAIN1 ,
, , , M- NTRAIN1 M- MEASURE
, M- MEASURE (Downstream) (SNR)
.

, (SU) (100) (80) S- TRAIN1 ,
S- NTRAIN1 , S- MEASURE (MU) , (M
U) (70) (M- NOSIG2) .

(MU) (70) S- TRAIN1
, , , , S- NTRAIN1 S- MEASURE
, S- MEASURE (Upstream) (SNR)
.

, (MU) (70) M- TRAIN2 , M- NTRAIN2 , M-
EXG , M- CRC (SU) , (SU)
(S- NOSIG2) . , M- TRAIN2 DMT (T_m
6) , 1000 2000 DMT .

, EXG MEASURE
, (DMT) 1 1
, " 0" T
RAIN " 1" NTRAIN .

, EXG MEASURE $b_i = \{b_0, b_1, b_2, \ldots, b_{255}\}$,
b_i $(m = \{m_{255*n}, \ldots, m_1, m_0\} = \{b_0, b_1, b_2, \ldots, b_{255}\})$
(m_k " 0" TRAIN , " 1" NTRAIN).

EXG DMT (T_m8) ,
256 4(3) , 768 (128× 3) DMT
.

, CRC EXG CRC(Cyclic Redundancy Check)
, CRC EXG EXG 1 2
.

1

$$c(D) = a(D) D^{16} \bmod ulog(D)$$

2

$$a(D)=a_0 D^{255 \cdot n}+a_1 D^{255 \cdot n-1}+...+a_{255 \cdot n}$$

, a(D) (Message Polynomial) , a $_0$ (Least Significant Bit) .

, g(D) CRC (Generator Polynomial) 3 , c(D) C
RC (Check Polynomial) 4 .

3

$$g(D)=D^{16}+D^{12}+D^5+1$$

4

$$c(D)=c_0 D^{15}+c_1 D^{14}+...+c_{14}D+c_{15}$$

, 4 c_0 c_{15} .

, (SU) (100) M- TRAIN2
, M- NTRAIN2 M- EXG , M- EXG
M- CRC (Bit Table) ((Power Table))
.

, (SU) M- CRC , S- TRAIN2 , S- NTRAIN2
, S- EXG , S- CRC (MU) , (MU)
(M- NOSIG3) .

, (MU) S- TRAIN2
, S- NTRAIN2 S- EXG , S- EXG S- CRC
.

, (MU) S- CRC , (SU) M
- TRAIN3 M- NTRAIN3 , (SU) (S-
NOSIG3) , M- NTRAIN3
.

,
,
(Time Slot) (Media S
ource)
.

, N (

sec) (3*N+ ??) , 4 5

,

(M- NOSIG, S- NOSIG)

4 .

.

,

,

, /

, .

(57)

1.

(PLC)

(DMT) ,

,

(SNR)
1 1

/ .

2.

1 , (Pilot)

/

.

3.

1 ,

,

/ .

4.

(PLC)

(DMT) ,

,

(AGC) , ,

,

(Time Marker) ,

,

1 1

,

CRC

/ .

5.

4 , ,

, ,

, ,

, ,

, ,

,

,

, ,

, ,

,

, ,

, CRC

,

, ,

, ,

,

, CRC

,

, ,

, ,

, ,

/

.

6.

4   ,   ,
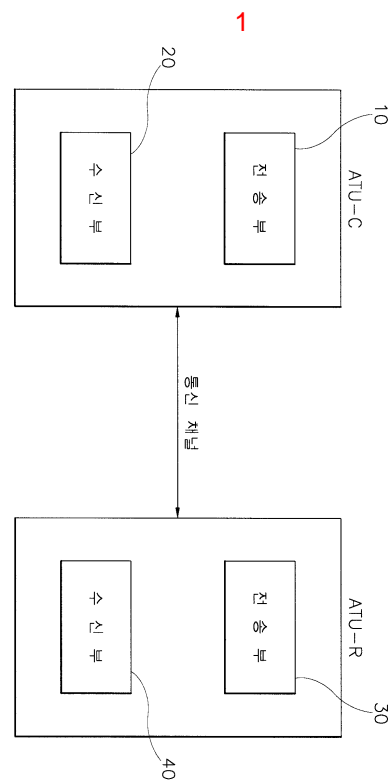
                                                (PRS)   2
4-   (QAM)   (Constellation Point)
              /   .

      7.

   4   ,   ,
,

                                              (+ ,+)
              /   .

      8.

   4   ,   ,

                      (PRS)   2   4-   (QAM)
(Constellation Point)   ,   1
                              /   .

1

2a

DMT 심벌수	ATU-C 전송부			ATU-R 전송부	DMT 심벌수
≦512 ≧128 ≦2048	C-QUIET2			R-QUIET2	≦8000
≦8516	C-PILOT1 or C-QUIET3	C-QUIET2	≧128		
			≦16 ≧512 ≦512		
		C-QUIET3A	≧496 ≦512		
512	C-REVERB1			R-REVERB1	4096
3072	C-PILOT2				
512	C-ECT			R-QUIET3	≧2047 ≦1056
1536	R-REVERB2				
512	R-ACK2 then C-PILOT3 R-ACK1 then C-QUIET5			R-ECT	512
1024	R-REVERB3			R-REVERB2	≧1024 ≦1056
512	C-SEGUE1			R-SEGUE1	10
1072	C-RATES1/C-CRC1 C-MSG1/C-CRC2			R-REVERB2	≧1092 ≦4000
			≧20 ≦2928	R-SEGUE2	10
				R-RATES1/R-CRC1 R-MSG1/R-CRC2	464
16384	C-MEDLEY			R-MEDLEY	16384

2b

			R—MEDLEY		
≧727 ≦2048	C—REVERB4		R—REVERB4	128	
			R—SEGUE3	10	
			R—MSG—RA/R—CRC—RA1 R—RATES—RA/R—CRC—RA2	15	
		≧80 ≦2413	R—REVERB—RA	≧227 ≦4000	
10	C—SEGUE2				
130	C—RATES—RA/C—CRC—RA1 C—MSG—RA/C—CRC—RA2				
≧163 ≦4000	R—REVERB—RA	≧64 ≦1447	R—SEGUE—RA	10	
			R—MSG2/C—CRC3 R—RATES2/C—CRC4	9	
10	C—SEGUE—RA	≧80 ≦2534	R—REVERB5	≧227 ≦4000	
9	C—MSG2/C—CRC3 C—RATES2/C—CRC4				
64	R—REVERB2				
≧586 ≦4000	R—REVERB5	≧64 ≦1383	R—SEGUE4	10	
			R—B&G/R—CRC5	512	
		≦2534	R—REVERB6	≦4000	
10	C—SEGUE3				
		≦2534	R—SEGUE5	10	
	SHOWTIME	최대 초기화 시간 11.3초	SHOWTIME		

도 3

4

마스터 유니트 　　　　　　 슬레이브 유니트

DMT 심벌수	마스터		슬레이브	DMT 심벌수
	M−NOSIG		S−TONES	T_s1
	≦T_lat			
T_m1	M−TONES		S−NOSIG1	≧ T_s2 ≦ T_s2+2"T_lat
T_m2	M−TRAIN1			
T_m3	M−NTRAIN1			
T_m4	M−MEASURE			
	≦T_lat			
≧T_m5 ≦T_m5+2"T_lat	M−NOSIG2		S−TRAIN1	T_S3
			S−NTRAIN1	T_S4
			S−MEASURE	T_s5
	≦T_lat			
T_m6	M−TRAIN2		S−NOSIG2	≧ T_s6 ≦ T_s6+2"T_lat
T_m7	M−NTRAIN2			
T_m8	M−EXG			
T_m9	M−CRC			
	≦T_lat			
≧T_m10 ≦T_m10+2"T_lat	M−NOSIG3		S−TRAIN2	T_s7
			S−NTRAIN2	T_s8
			S−EXG	T_s9
			S−CRC	T_s10
	≦T_lat			
T_m11	M−TRAIN3		S−NOSIG3	≧T_s11 ≦ T_s11+2"T_lat
T_m12	M−NTRAIN3			

초기화 완료