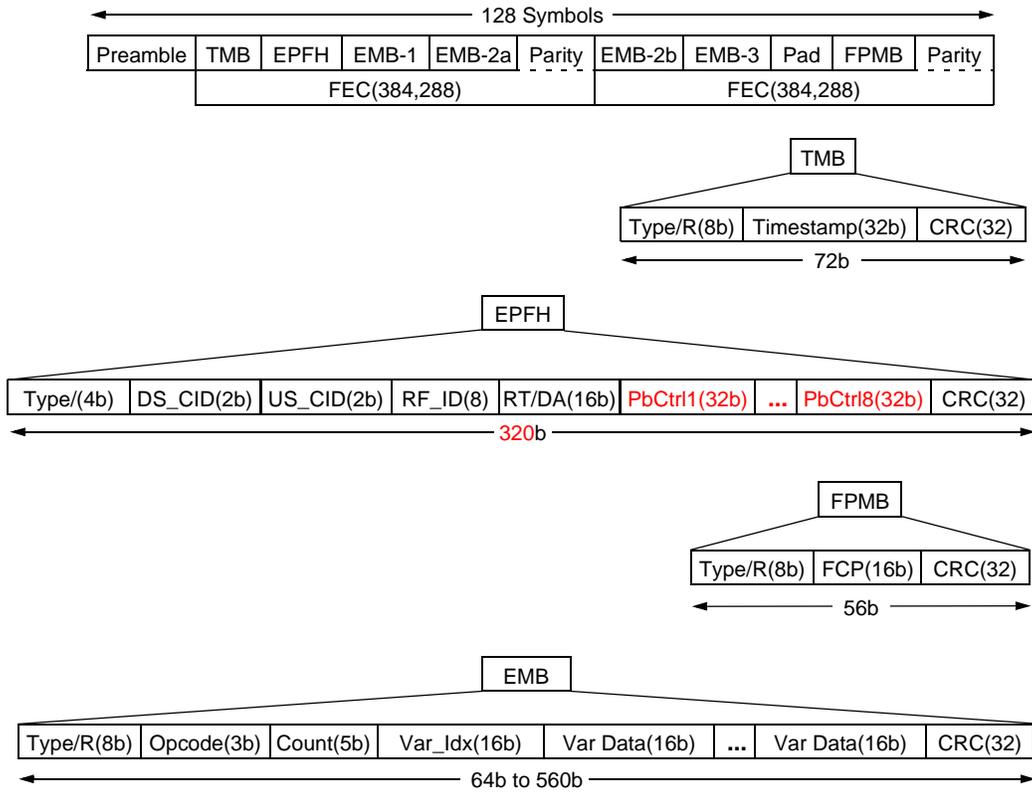


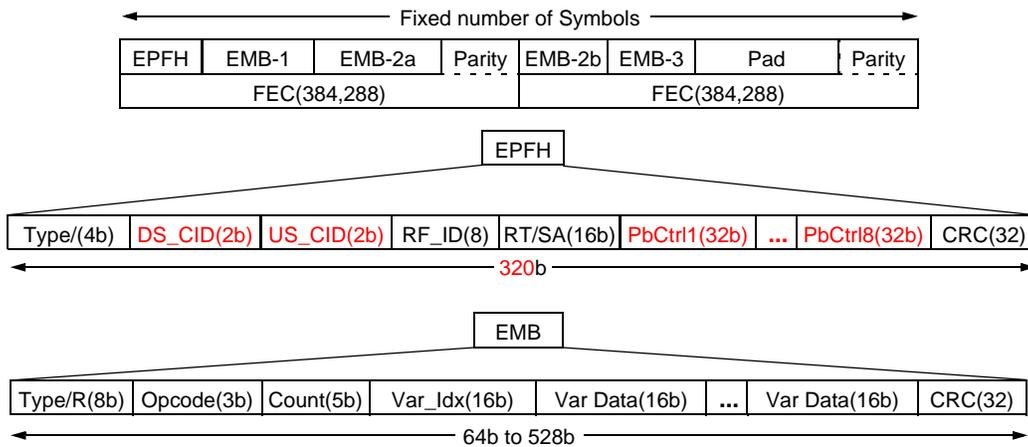
## 102. EPoC PHY Link

*Modify Figure 102-1 and 102-2 as shown below*



**Figure 102–1—Downstream PHY Link frame**

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**Figure 102–2—Upstream PHY Link frame**

*Modify 102.2.3 as shown below*

### 102.2.3 DS frame

The downstream PHY Link uses a fixed frame format, illustrated in Figure 102–1, that the 128 symbol staggered pilot pattern is aligned with, as described in 101.4.3.5.1. The 128 symbol downstream PHY Link frame is composed of a Preamble (see 102.2.2), one 32-bit Timestamp message block (TSMB), one 320-bit EPoC PHY Frame Header (EPFH), some number of variable length EPoC message blocks (EMP), one 56-bit FEC Parity message block (FPMB), and padding. The message blocks within the frame are protected with a FEC mechanism. Each message block and its included fields is described below. The number of optional EPoC message blocks contained within the frame is limited only by the frame size.

Each message block contains a Type field used to identify the contents of the block. CLTs shall use the appropriate message Type fields listed in Table 102–6 in each message block.

*EDITORS NOTE (to be removed prior to publication): if we need to include message block Types defined in D3.1 the above table will need modification. D3.1 include the following:*

*Type 1 = Time Stamp MB with 24b CRC*

*Type 2 = Energy Management MB*

*Type 3 = MC MB*

*Type 4 = Trigger MBDS fixed header*

*Move 102.2.3.1.2 “DS Timestamp message block” here renumbering as shown below, text and figures are not changed.*

#### 102.2.3.1 DS Timestamp message block

The Timestamp message block includes a Type field, the PHY Timestamp field and a CRC(32). The PHY Timestamp is a 32 bit field which the EPoC PHY uses to synchronize the US PHY Link frame and OFDMA symbols. The counter is clocked from the 204.8 MHz OFDM clock. When a CNU PHY that has TxEnable equal to False receives a PHY Frame addressed to it or to the broadcast address it shall reset its local timestamp to the value in the Timestamp. The reference point for the Timestamp shall be the first sample of the PHY Link symbol immediately following the Preamble (Figure 102–13). For additional information on the use of the Timestamp see [ref.].

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The contents of the Timestamp message block is protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

*Move 102.2.3.1.2 “DS EPoC PHY Frame Header” here renumbering and changing text and figures as shown below.*

### 102.2.3.2 DS EPoC PHY Frame Header

The EPoC PHY Frame Header includes a Type field, the Configuration ID fields (DS\_CID and US\_CID), the Return Frame ID field (RF\_ID), the Response Type field (RT), the PHY Link DA field, Probe Control fields 1 through 8 (PbCtrl) , and a CRC(32) as illustrated in Figure 102–1.

The Configuration ID fields are two bit fields used to inform a CNU, to switch from one modulation profile to another. There is one field for control of the downstream profile (DS\_CID) and one field for the upstream profile (US\_CID). Each CNU contains two profiles in each direction, copy “A” and copy “B”; only one of which is active at any given time. The CLT updates the unused profile then, using the PHY Configuration ID field, switches the CNU to the updated profile. Once the CLT begins the switchover, as indicated by Configuration ID field values 0b01 or 0b10 it shall complete the switchover. During a switchover the value of the Configuration ID field is either incremented or decremented by one in each successive frame; thus a switchover takes three PHY Link frame times. Table 102–7 summarizes the use and meaning of the PHY Configuration ID bits and their operation is illustrated in Figure 102–12.

In the downstream direction the new profile is activated at the first symbol (i.e., the symbol containing the PHY Link Preamble) in the next PHY Link frame. In the Upstream direction the new profile is activated in the first symbol of the Probe Period following the frame identified by the Return Frame ID field.

*EDITORS NOTE (to be removed prior to publication): Definitions and normative text needed to explain and define the modulation profile and its' requirements.*

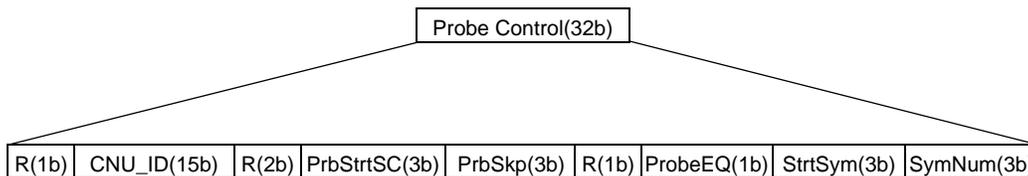
The Response Frame ID (~~RF\_ID~~) field is an eight bit field which indicates to the receiving CNU which OFDMA frame to use for the response message to this frame. The CLT shall ensure that all CNUs have sufficient time (as determined by the variable PhyLnkRspTm) to response to the DS PHY Link frame.

*Added last sentence regarding response time, can leave as a read/only variable set by the CNU vendor or fix a time in the std for max response time. If fixed 1-2 OFDM symbols is suggested.*

The Response Type (RT) field is a one bit field which indicates the signal type of response the CLT is expecting; possible responses are PHY Link message (RT = true) or Fine Ranging / PHY Discovery (RT = False). The contents of the message will differentiate between Fine Ranging and PHY Discovery signaling types. When the Response Type field indicates Fine Ranging / PHY Discovery the Response Frame should be set to zero and is ignored on reception as these signaling types have fixed starting points.

The PHY Link DA is an address field that identifies the CNU that the PHY frame is targeted for. This field is 15 bits and may be a unicast address or a broadcast address (see Table 102–8). In the CNU if the DA does not match the assigned address or the broadcast address then the frame is discarded and no response is made. The CLT shall only transmit the valid values of the PHY DA as given in Table 102–8.

The Probe Control fields (1 through 8) each enable one CNU to participate in the first Probe Period of the upstream frame following the Response Frame ID. Each Probe Control contains a PrbID, PrbStrtSC, PrbSkip, PrbEQ, StrtSym, SymNum, and several reserved (R) subfields as illustrated in Figure 102–3. To enable a CNU to participate in a Probe Period the CNU\_ID of the participating CNU is placed in PrbID subfield of the Probe Control. The remaining subfields set the corresponding variables in the designed CNU. A Probe Control field set to all zeros or any broadcast CNU\_ID does not enable any CNU. For additional information on use of the Probe Control fields see 102.3.3.3.



**Figure 102–3—Probe Control**

The contents of the PHY Frame Header is protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

*Move 102.2.3.2 “DS EPoC message block” here renumbering and modifying text as shown below.*

### 102.2.3.3 DS EPoC message block

The downstream EPoC message block contains a Type field (see Table 102–6), a PHY Instruction, and a CRC(32).

The CLT can perform read and write operations on the EPoC Variables of subtended CNUs via PHY Instructions. Each instruction contains an OPCODE, a Variable Group Count, a Variable Index and up to 31 Variable Group Data fields.

The PHY Link OPCODE is a 3 bit field that conveys the operation of the PHY Instruction in which it resides. The CLT shall only transmit the valid values of the PHY DA and OPCODE fields as given in Table 102–8, and Table 102–9 respectively.

The Variable Group Count field specifies the number of 16-bit EPoC Variable groups contained in a write or write/verify PHY Instruction or the number of 16-bit EPoC Variable groups that are to be returned in a read or write/verify PHY Instruction. The Variable Group Count field has a value of 0 to 31. The Variable Group Count field in a NOP instruction always has a value of 0. Whereas, for a read, write or write/verify instruction the Variable Group Count always has a value between 1 and 31.

The 16-bit EPoC Variable Index field specifies the variable group at which the CNU is to begin the read, write or write/verify operation. The NOP instruction does not include an Index field.

The 16-bit Variable Group Data fields contain the data values to be written in consecutive variable groups starting with the group indicated by the Variable Index field and continuing for the number of groups indicated by Variable Group Count of the target CNU. The Variable Group Data fields are valid only for a write or write/verify PHY Instructions; or in the response to a read or write/verify PHY Instruction. In the event there is a discrepancy between the Variable Group Count field and the number of 16-bit Variable Group Data fields the CNU shall write no data to its variables and returns a Nack indication (see 102.3.2.2).

The contents of the EPoC message block is protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

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*Move 102.2.3.1.4 “DS Padding” here renumbering and modifying text as shown below.*

#### **102.2.3.4 DS Padding**

The Pad field is used to fill the PHY frame in the event there are unused bits after the message blocks and FEC fields have been populated. The Pad field consists of all zeros and is ignored upon receipt.

*Move 102.2.3.1.3 “DS FEC Parity message block” here renumbering and modifying text as shown below.*

#### **102.2.3.5 DS FEC Parity message block**

The FEC Parity message block includes a Type field, the FEC Codeword pointer and a CRC(32). The FEC Codeword Pointer (FCP) is a 16-bit field used to identify the start of the first FEC codeword in the next PHY Link frame. The contents of the FEC Parity message block is protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

*Move 102.2.4 “DS PHY Link FEC” here renumbering as shown below. Text remains unchanged.*

#### **102.2.3.6 DS PHY Link FEC**

The downstream PHY Link shall use a (384,288) binary punctured LDPC code described in 102.1.4.1.1 and 102.1.4.2.1.

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*Modify section 102.3.2 as shown below.*

### **102.3.2 US Frame**

The upstream PHY Link frame is composed of the EPoC PHY Frame Header, optional EPoC message blocks and a FEC. These messages are described below.

Each message block contains a Type field used to identify the contents of the block. CNU shall use the appropriate message Type fields listed in Table 102–6 in each message block.

#### **102.3.2.1 US EPoC PHY Frame Header**

The upstream PHY Frame Header includes a Type field, Return Frame ID field, Response Type field, the PHY SA, Probe Control fields and a CRC(32). The Type field, the Return Frame ID field, the Response Type field and Probe Control fields are echoes of the same fields in the downstream message to which the CNU is responding. The PHY SA is an address field that identifies the CNU transmitting the PHY frame. This field is 15 bits and is always the unicast address associated with the CNU transmitting in the PHY Link (see Table 102–8). The CNU SA is assigned during the PHY Discovery process (see 102.4.1).

The contents of the PHY Frame Header are protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

#### **102.3.2.2 US EPoC message block**

The EPoC message block contains a Type field (see Table 102–6), the PHY Response and a CRC(32).

Each PHY Response is composed of an OPCODE, a Variable Group Count, a Variable Group Index, and 0 to 31 Variable Group Data fields. There is a one to one correspondence between PHY Instructions in the downstream PHY Link and PHY Responses in the upstream PHY Link.

If the downstream PHY Link EPoC PHY Frame Header contains the unicast CNU\_ID for the CNU, the addressed CNU shall respond to PHY Link instructions using the PHY Response. Each Response contains an OPCODE, a Variable Group Count, a Variable Group Index and up to 31 Variable Group Data fields.

The PHY Response OPCODE is a 3 bit value that conveys the acknowledge type for PHY Instruction to which the CNU is responding and the success or failure of the PHY Instruction command. CNU shall use the valid values of the acknowledgment type given in Table 102–11.

The Variable Group Count field specifies the number of 16-bit variable groups that are being returned in response to a read or write/verify PHY Instruction. In the event the CNU is returning a Nack response (Acknowledgment values 0b100 through 0b0111) the Variable Group Count field shall be set to zero and is ignored at the CLT.

The 16-bit Variable Group Index field specifies the first index for which the CNU is returning data due to a read or write/verify operation or the first index of the corresponding write Instruction.

The 16-bit Variable Group Data fields contain the data values read from the variables due to a read or write/verify PHY Instruction. In the event the CNU is responding to a write instruction this field is omitted. The Variable Group Data field should be omitted in Nack Responses (Acknowledgment values 0b100 to 0b111) and, if included, shall be ignored at the CLT.

The contents of the EPoC message block is protected by a CRC(32). See 3.2.9 for a description of how this field is calculated.

### 102.3.2.3 Padding

The Pad field is used to fill the PHY frame in the event there are unused bits message blocks and FEC fields have been populated. The Pad field consists of all zeros and is ignored upon receipt.

*Move 102.3.3 “US PHY Link FEC” here renumbering as shown below. Text remains unchanged.*

### 102.3.2.4 US PHY Link FEC

For normal data transfers the upstream PHY Link shall use a (384,288) binary punctured LDPC code described in 102.1.4.2.1.

*The statement below should be moved to an appropriate location in 102.4.1.4 “PHY Link Discovery Response”*

For PHY Discovery data transfers the upstream PHY Link shall use a (128,80) binary punctured LDPC code described in 102.1.4.2.2.

*The statement below should be removed (see comment against 102.3.3 pg 186 line 50).*

For Fine Ranging data transfers the upstream PHY Link shall use a (362,272) binary punctured LDPC code described in 102.1.4.2.3

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*Modify section 102.4.3 as shown below.*

### 102.3.3 Upstream Wideband Probing

#### 102.3.3.1 Introduction

In upstream wideband probing a CNU transmits pilots spanning all active subcarriers. The CNU transmits one pilot per subcarrier. Each pilot is a predefined BPSK symbol. Each upstream superframe begins with 5 or 6 symbols, called the Probe Period, designated for probing. Each symbol within the Probe Period is referred to as a probing symbol and the number of symbols in the Probe Period is set via the ProbDur variable. The CLT uses the received probing symbol for:

- 1) Upstream channel estimation. The CLT computes the coefficients of the upstream pre-equalizer for each CNU and sends them back to that CNU.
- 2) Upstream SNR measurement. The CLT measures the SNR per subcarrier and computes the upstream bit loading tables.

#### 102.3.3.2 Probing symbol pilots

Probing symbol pilots are BPSK symbols.

Probing symbol pilot  $i$  is always associated with the  $i$ -th subcarrier of the symbol, where:

$$i = 0, 1, \dots, 4095$$

(Subcarriers are numbered in ascending order of frequency starting from 0.)

#### 102.3.3.3 Probing symbol scheduling

The CLT may allocate a one or more probing symbols to a CNU within the Probing Period and instruct the CNU to transmit the probing sequence in that symbol. CLT specifies the probing symbols within the Probing Period via the Probe Control fields in the downstream PHY Link frame. The CLT assigns a CNU either all the pilots of the assigned probing symbols, or a subset of (scattered) pilots of the assigned probing symbols.

The CLT allocates subcarriers within a probing symbol by sending five variables to the CNU: PrbStrtSC, PrbSkp, PrbEQ, StrtSym and SymNum (see 102.4.3.6). Figure 102–4 and Figure 102–5 illustrate the use of PrbStrtSC and PrbSkp. The CNU uses the start subcarrier and subcarrier skipping parameters to determine which subcarriers are to be used for probing transmission, as follows:

- The PrbStrtSC variable is the starting subcarrier number.
- The PrbSkp variable is the number of subcarriers to be skipped between successive pilots. PrbSkp = 0 implies no skipping of subcarriers (i.e., all subcarriers are used for probing).

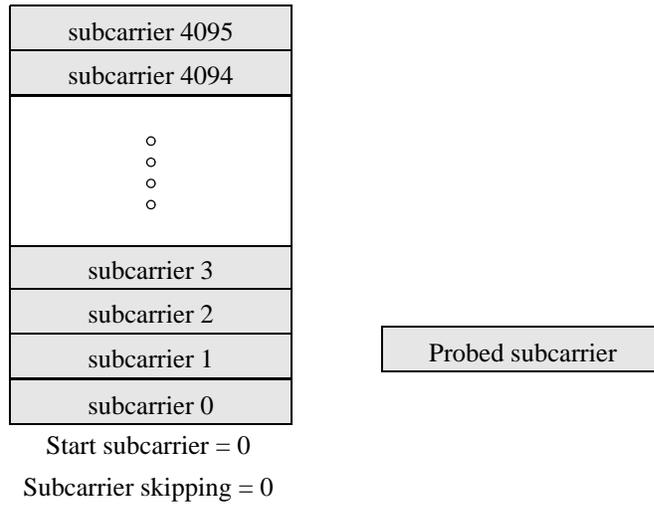


Figure 102-4—Example, all subcarriers used for probing, no skipping

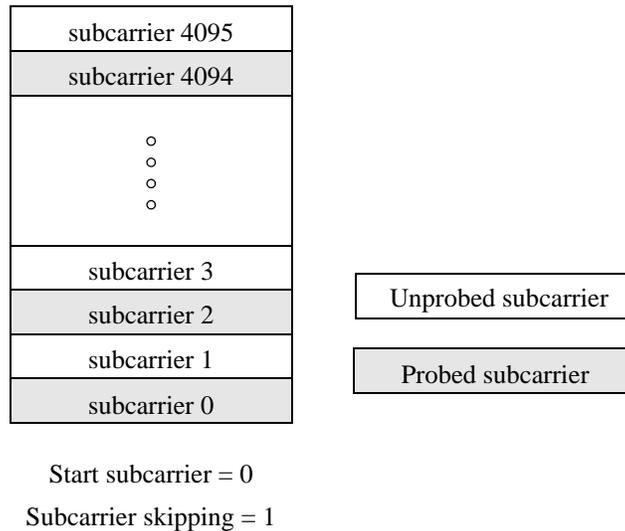


Figure 102-5—Example, alternate subcarriers used for probing

To schedule a single CNU in a probing symbol without skipping subcarriers, the CLT does the following:

- 1) Allocate a specific probing symbol to a single CNU.
- 2) Set PrbSkp to zero.
- 3) Set PrbStrtSC to the number of the first subcarrier.

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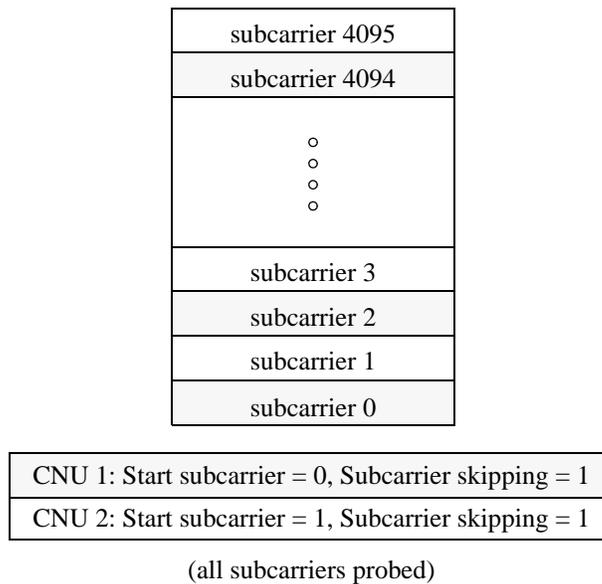
To schedule a single CNU in a probing symbol with skipping subcarriers to create nulls (as illustrated in Figure 102–5), the CLT does the following:

- 1) Allocate a specific probing symbol to a single CNU.
- 2) Set PrbSkp to a non-zero positive integer value.
- 3) Set PrbStrtSC to the number of the first subcarrier.

To schedule multiple CNUs in a probing symbol (as illustrated in Figure 102–6) the CLT does the following:

- 1) Allocate the same probing symbol at any given time to more than one CNU.
- 2) Assign a different PrbStrtSC number to each CNU.
- 3) Assign the same PrbSkp value to every CNU within the probing symbol.

This method can be used with or without skipping subcarriers to create nulls. To create nulls, specify a PrbSkp value equal to, or greater than, the number of CNUs in the pattern.



**Figure 102–6—Scheduling two CNUs in the same probing symbol**

The PrbEQ variable determines if the pilots transmitted are to be equalized (PrbEQ TRUE) or un-equalized (PrbEQ FALSE).

StrtSym and SymNum variables determine which symbols within the Probe Period are to be used by the CNU. The value of StrtSym determines the first symbol within the Probe Period to begin probe transmissions and SymNum determines the number of adjacent symbols in which to send probe pilots. The CLT is responsible for properly setting the Probe Control field so that the probe pilots are defined within the configured Probe Period. The CNU shall not transmit probe pilots in response to settings which define transmission outside the configured Probe Period. For example if StrtSym is set to 6 while the Probe Period is only 5 Symbols long or StrtSym equal 4 and SymNum equals 3 the CNU does not transmit any probe pilots. The CNU is not responsible for crosschecking Probe Control settings to ensure that no two CNUs are assigned

the same subcarriers for probing. Should the CLT make such an assignment it will receive a garbled response.

### 102.3.3.4 Probing sequence

The Probe symbol shall be populated with a BPSK mapped bit sequence generated by a pseudo-random sequence generator defined by the polynomial  $X^{12} + X^9 + X^8 + X^5 + 1$  seeded with a fixed bit pattern of 0xBFF at the beginning of each upstream superframe (illustrated in Figure 102–7). The output of the sequence generator is mapped using BPSK modulation (see 101.4.5.2) where a bit value of 0 is mapped to a BPSK value of plus1 and a bit value of 1 is mapped to a BPSK value of minus 1.

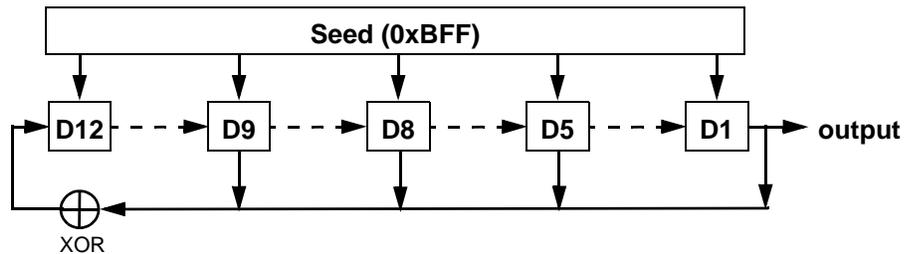


Figure 102–7—Probe sequence generator

### 102.3.3.5 Probe symbol repetition

Probes use all active subcarriers of a symbol. The first symbol in a Probe is generated as described in 102.3.3.4. The second symbol is a direct copy of the first symbol.

*EDITORS NOTE (to be removed prior to publication): the above statement, generated as a result of Norfolk motion #4, works well for probes using 2 symbols but it is not clear how 3 or 4 symbol probes are generated. Is the first symbol repeated N times or is the 3rd symbol a new pattern output from the seq. generator?*

### 102.4.3.5 placeholder

*Add section 102.4.3.6 through 102.4.3.9 as shown below.*

*NOTE: not all these variables need to be included in CI 45. We need to determine how to index variables that need to be communicated over the PHY Link that are not included in CI 45. Current “rule” is:*

*if 1.1900 <= RegAdd <=1.1999 Then Index = RegAdd - 1.1900)\*1000 (i.e., 0-99)*

*if 12.0000 <= RegAdd Then Index = (RegAdd - 12.0000)\*1000 + 100 (i.e., 100 + )*

### 102.4.3.6 Variables

ActPrbID

TYPE: set of 15-bit Integers

When this CNU\_ID is contained in this set of variables the CNU is allowed to transmit a Probe Signal per the Probe Control variable PrbEQ, PrbSkp, PrbStrtSC, StrtSym and SymNum. This set of variables is updated with each downstream PHY Link frame when RF\_ID = US\_FmCnt (See Figure 102–9).

CNU_ID		1
	See {ref}	2
PrbData		3
	TYPE: bit array	4
	This variable holds the probe sequence bits to be transmitted during the probe period.	5
ProbeDur		6
	TYPE: boolean	7
	This variable determines the number of Symbols in the Probe Period. When ProbeDur is FALSE there are five symbols in the Probe Period, when this variable is TRUE there are six symbols in the Probe Period.	8
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PrbEQ		12
	TYPE: Boolean	13
	When this variable is TRUE the CNU transmits the probe symbol with equalization applied.	14
	When this variable is FALSE the CNU transmits the probe symbol without equalization applied.	15
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	<i>Note the def for PrbEq is included here for clarity but should be placed in Cl 101.4.4.5 Probe generator.</i>	18
PrbSkp		19
	TYPE: Integer	20
	The value of this variable determines the number of subcarriers to be skipped in the probe symbol. The range of PrbSkp is from zero to seven.	21
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PrbStrtSC		24
	TYPE: Integer	25
	The value of this variable determines the starting subcarrier to be used in the probe symbol. The range of PrbStrtSC is from zero to seven.	26
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RcvPrbID		29
	TYPE: set of 15-bit Integers	30
	This set of variables contains the received set of PrbID variables from the most recent downstream PHY Link frame. PrbID. When US_FrmCnt = RF_ID the values in this set replaces the values in the ActPrbID set. (see Figure 102–9).	31
		32
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StrtSym		34
	TYPE: Integer	35
	The value of this variable determines the starting symbol within the Probe Period in which to begin transmitting probe pilots. The range of this variable is from one to six.	36
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SymNum		39
	TYPE: Integer	40
	The value of this variable determines the number of consecutive symbols in which to transmit probe pilots. The range of this variable is from one to six.	41
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		43
<b>102.4.3.7 Counters</b>		44
		45
SC_Cnt		46
	TYPE: 12-bit	47
	This counter tracks the subcarriers within each symbol. Subcarrier zero is the first subcarrier while subcarrier 4096 is the last.	48
		49
US_FmCnt		50
	See 102.3.4.2.	51
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**102.4.3.8 Functions**

Mod(x,y)

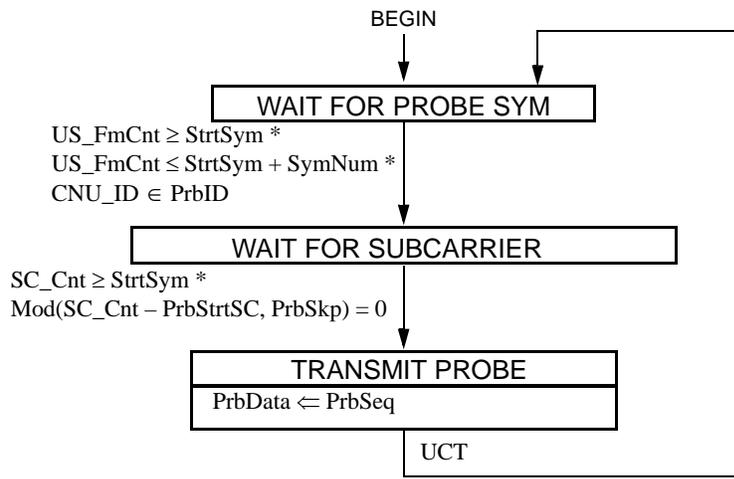
This function returns the remainder of x divided by y.

PrbSeq

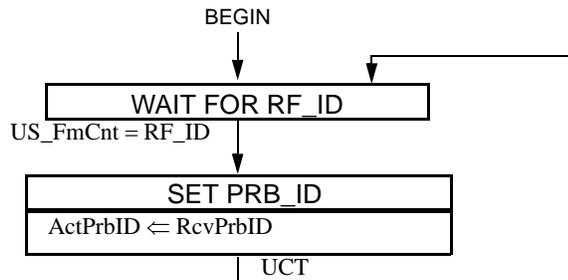
This function returns one symbols worth of probe data using the sequence generator described in 102.4.3.4.

**102.4.3.9 State Diagrams**

The CNU probe transmit process shall conform to the state diagram shown in Figure 102–8.



**Figure 102–8—CNU Probe transmission control state diagram**



**Figure 102–9—PrbID update state diagram**

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