LOW-LATENCY

MODIFIED mN/mN+1 ENCODING

CAPABLE TO PROCESS ON COUPLES OF CONTROL

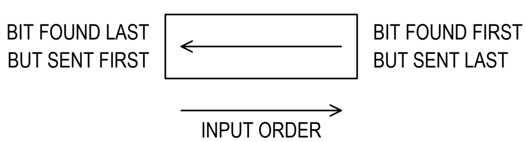
I. FOUNDATION

The encoding method described further in this memo mimics for the 8N/8N+1 encoding introduced (invented?) by William Lo during the time of IEEE P802.3bp task force [1, 2], with the following modifications.

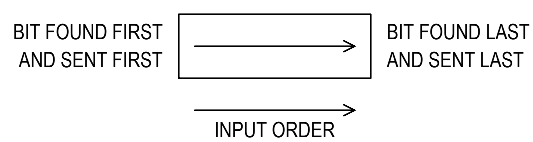
[1] https://www.ieee802.org/3/bp/public/mar14/Lo_3bp_02_0314.pdf (1000BASE-T1 PHY Encoder Proposal For Gigabit MAC Compatibility, March 2014)
[2] https://www.ieee802.org/3/bp/public/may14/Lo_3bp_01_0514.pdf (Correction to 1000BASE-T1 PHY 8N/8N+1 Encoder Equations, May 2014)

First, it treats on the input left to right, instead of right to left as in [1, 2], to decrease the transmit (encoding) delay, namely the argument accumulation delay.

<u>ORIG. mN/mN+1 ENC.</u>

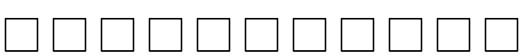


<u>MOD. mN/mN+1 ENC.</u>

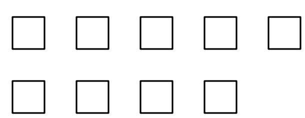


Second, it constructs the output in a tabular manner, with functionally natural rows of bits, instead in a bit stream manner as in [1, 2], that simplifies its description and reception.

<u>ORIG. mN/mN+1 ENC.</u>



<u>MOD. mN/mN+1 ENC.</u>



Third, it provides extra signaling options, obvious with its row-based definition but hardly seen with a bit stream-based definition as in [1, 2], in the form of forced output samples.

At the same time, like [1, 2], it treats on an input stream of independent transfer units, in singles if data, that is again like in [1, 2], but in couples if control, that is new to [1, 2].

Last but not least, this method is designed to be operationally compatible with the long-reach coupled encoding method — by providing the same number of and resolution for control symbols, which are eight items and half the octet time (one MII input cycle time or one transfer unit time), respectively. Also, the bit capacities of the forced output of the methods are in an integral proportion of 1 to 4, i.e., 12 bits to 48 bits in the low-latency and long-reach cases, respectively.

II. PRINCIPLES OF OPERATION — ENCODING PATTERNS, N=4

In the tables below, encoding input patterns for a span of N = 4 transfer units are listed. **There are only eight to support.** (Here and further C and c mean the same, i.e., control.)

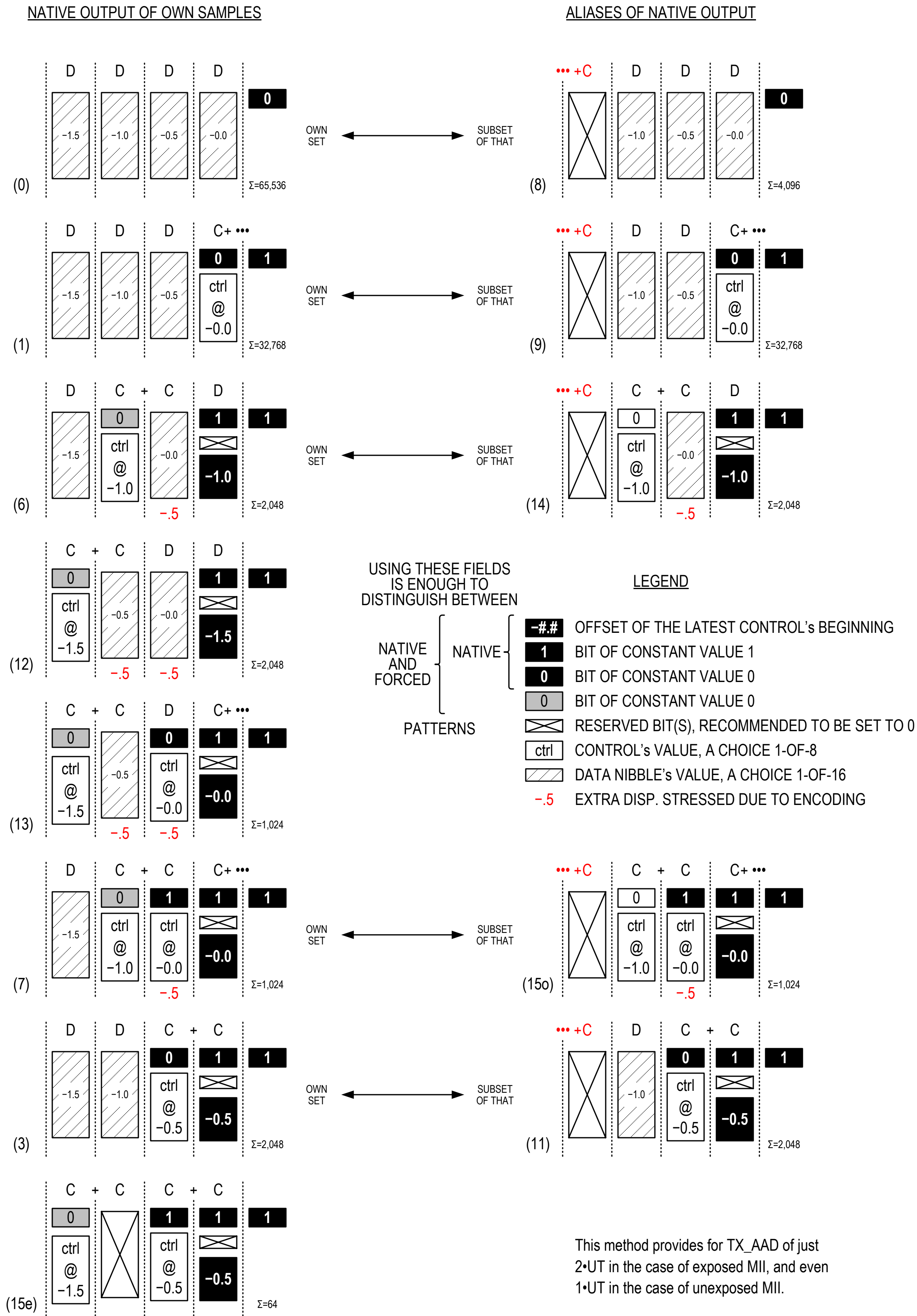
TRANSFER SPAN PATTERNS

	PATTERN	ASSUMED AS	INVARIANT	STRICT EVEN	STRICT ODD	MIXED
(0)	D D D D	D D D D	D D D D	—	—	—
(1)	D D D c	D D D c+•••	—	—	D D D c+•••	—
(2)	D D c D	*MUST BE TREATED AS DDcc OR DccD DEPENDING ON THE CURRENT EVEN/ODD ORDER*				
(3)	D D c c	D D c + c	—	D D c + c	—	—
(4)	D c D D	*MUST BE TREATED AS DccD OR ccDD DEPENDING ON THE CURRENT EVEN/ODD ORDER*				
(5)	D c D c	*MAY BE TREATED AS cccc OR Dccc OR ccDc DEPENDING ON THE CURRENT ENCODING CONTEXT*				
(6)	D c c D	D c + c D	—	—	D c + c D	—
(7)	D c c c	D c + c c+•••	—	—	D c + c c+•••	—
(8)	c D D D	••• + c D D D	—	—	••• + c D D D	—
(9)	c D D c	••• + c D D c+•••	—	—	••• + c D D c+•••	—
(10)	c D c D	*MAY BE TREATED AS cccc OR cccD OR cDcc DEPENDING ON THE CURRENT ENCODING CONTEXT*				
(11)	c D c c	••• + c D c + c	—	—	—	••• + c D c + c
(12)	c c D D	c + c D D	—	c + c D D	—	—
(13)	c c D c	c + c D c+•••	—	—	—	c + c D c+•••
(14)	c c c D	••• + c c + c D	—	—	••• + c c + c D	—
(15e)	c c c c →	c + c c + c	—	c + c c + c	—	—
(15o)	↘	••• + c c + c c+•••	—		••• + c c + c c+•••	—
	16 TOTAL	11 + 1e + 1o	1 OUT OF 16	3 OUT OF 16	7 OUT OF 16	2 OUT OF 16

TREATABLE PATTERNS

	PATTERN	TREATED AS			ITS ALIAS	BECAUSE TREATED AS
(0)	D D D D	D D D D	↔	(8)	c D D D	~~••• + c~~ D D D D
(1)	D D D c	D D D c+•••	↔	(9)	c D D c	~~••• + c~~ D D D c+•••
(3)	D D c c	D D c + c	↔	(11)	c D c c	~~••• + c~~ D D c + c
(6)	D c c D	D c + c D	↔	(14)	c c c D	~~••• + c~~ D c + c D
(7)	D c c c	D c + c c+•••	↔	(15o)	c c c c	~~••• + c~~ D c + c c+•••
(12)	c c D D	c + c D D				
(13)	c c D c	c + c D c+•••				
(15e)	c c c c	c + c c + c				
	(7 + 1e =) 8 OUT OF 17 (= 15 + 2)				(4 + 1o =) 5 OUT OF 17 (= 15 + 2)	

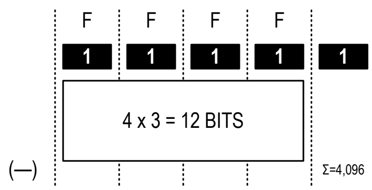
II. LOW-LATENCY COUPLED ENCODING, 16B/17B, UT=4BT — DESCRIPTION AND DEFINITION, PART 1 OF 2



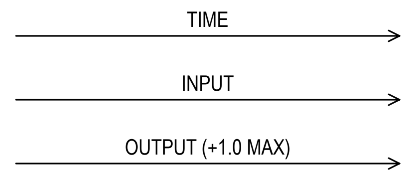
This method provides for TX_AAD of just 2•UT in the case of exposed MII, and even 1•UT in the case of unexposed MII.

II. LOW-LATENCY COUPLED ENCODING, 16B/17B, UT=4BT — DESCRIPTION AND DEFINITION, PART 2 OF 2

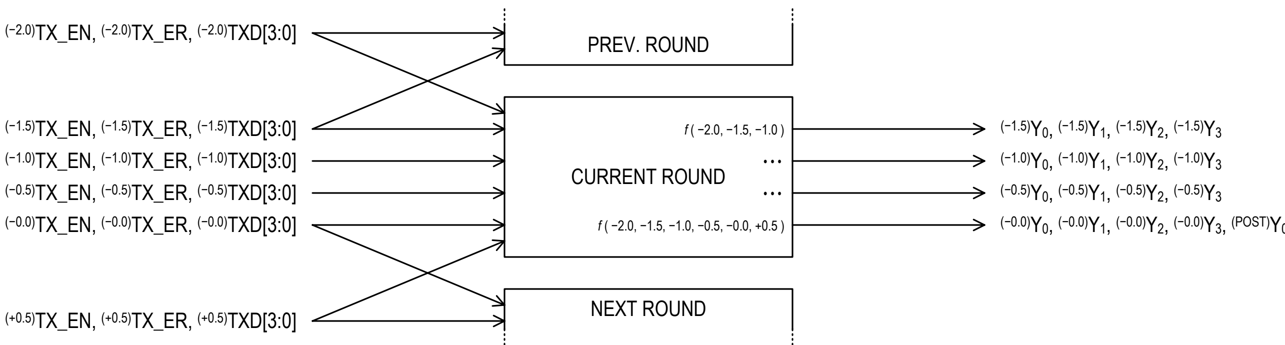
FORCED OUTPUT (OWN SAMPLES)



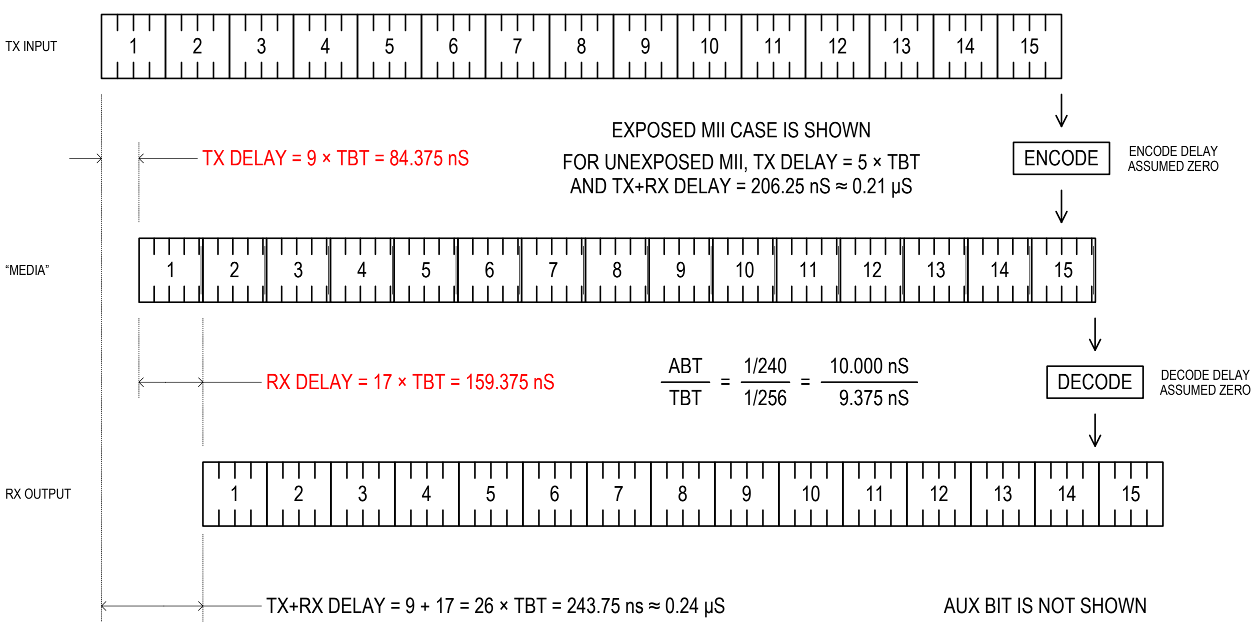
ORDERS



FUNCTION



CODING DELAYS

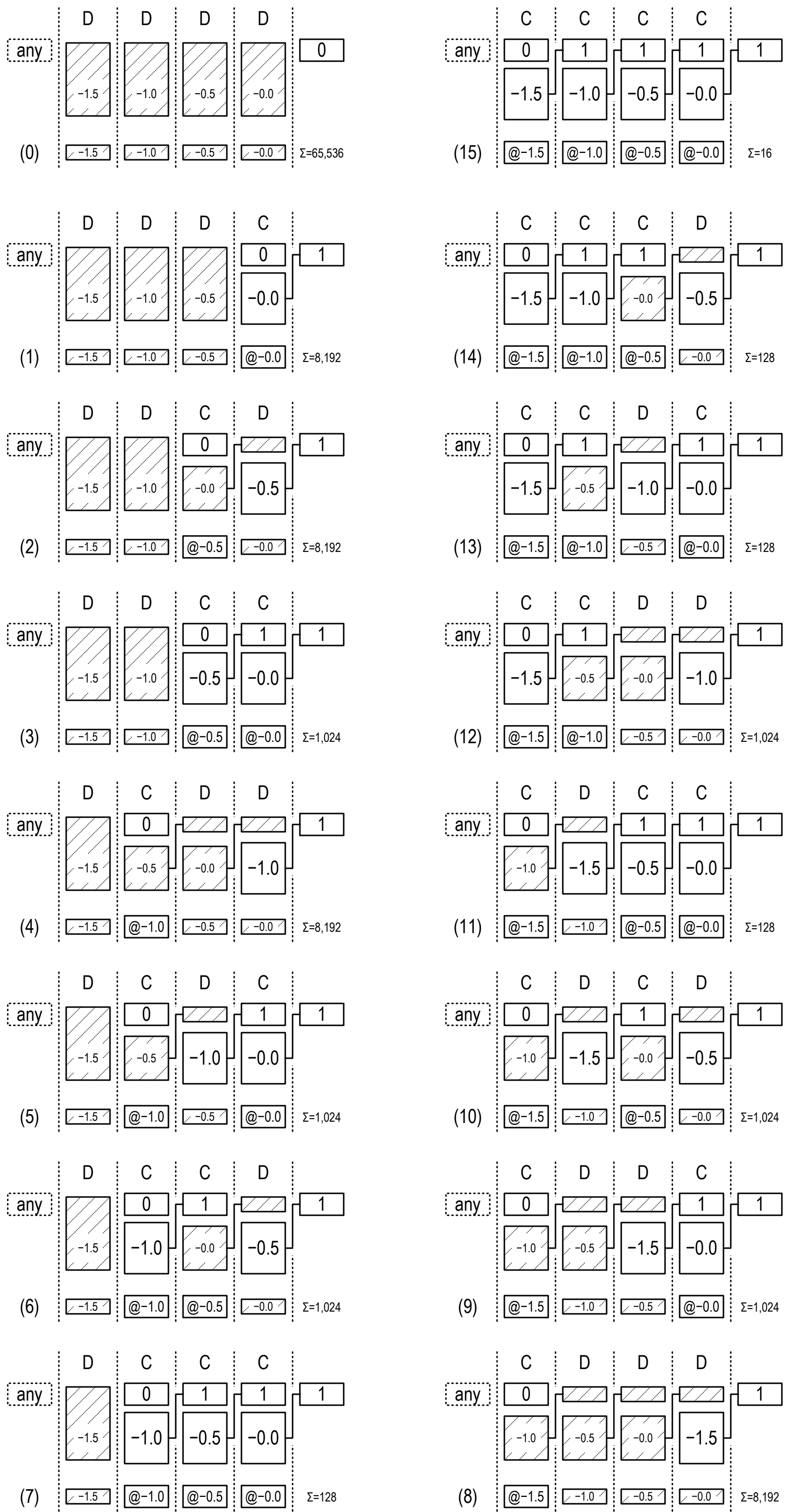


NOTE — TRANSFER UNIT TIME (UT) = NIBBLE TIME = FOUR BIT TIMES = 4 × ABT = 40 nS.

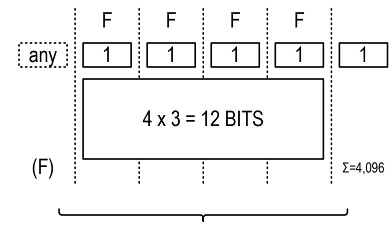
NOTE — ALL SHOWN DELAYS ARE CONSTANT AND FRAME CONTENT-INDEPENDENT.

III. LOW-LATENCY ENCODING, 16B/17B, UT=4BT — ALTERNATIVE APPROACH, NO NIBBLE COUPLING AT ALL

NATIVE SAMPLES — ALL 16 POSSIBLE PATTERNS ARE USED



FORCED SAMPLES



MAY BE USED FOR:

LPI
OAM
ORDERED SET
EVENTS, E.G., SYCHRONIZATION
EMERGENCY, E.G., BREAK
PREEMPTION
OTHER “RARE” CASES

If all bits of PBR are set, it is a forced output sample. Otherwise, it is a native sample. For representation, only horizontal adjacent bit swaps in PBR and TLR are necessary. Bits of FFR are not swapped at all.

← PIT/BATON ROW (PBR)

← TRACK/LEG ROW (TLR)

← FAN/FAN ROW (FFR)

This method provides for TX_AAD of just 2•UT in the case of exposed MII, and even 1•UT in the case of unexposed MII.

CONTROL DEFINITION

$0 \le C_1, C_2 \le 1,\ C_1 \ne C_2$

ctrl@ { C_1 DATA ERROR; C_2 NORMAL IDLE

(USED 99.99% OF TIME)