DVMEGA

the Swiss army knife for Digital Voice

Guus van Dooren

PE1PLM

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- ***Introduction***
- ***Goal DVMEGA project***
- ***DVMEGA evolution***
- ***Development challenges***
- ***DV protocol example***
- ***Under development***

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Introduction

- *Guus van Dooren*
- *PE1PLM, Full license since 1996*
- *Industrial Engineer*
- *1990 – 1997, Compact disc development at Philips Eindhoven*
- *1998 – 2000, Project leader payment systems at Schlumberger*
- *2000 – today, Owner of Dooren Electronic Solutions*

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Goal DVMEGA project

- *Learning Digital Voice modes and protocols*
- *Stimulate homebrew of ham-related products*
- *Provide affordable DV related kits*
- *DV node adaptor for high power radiohotspot*
- *Low power DV radio hotspot*
- *Direct Digital Voice Device, DV IP radio*
- *Arduino based*

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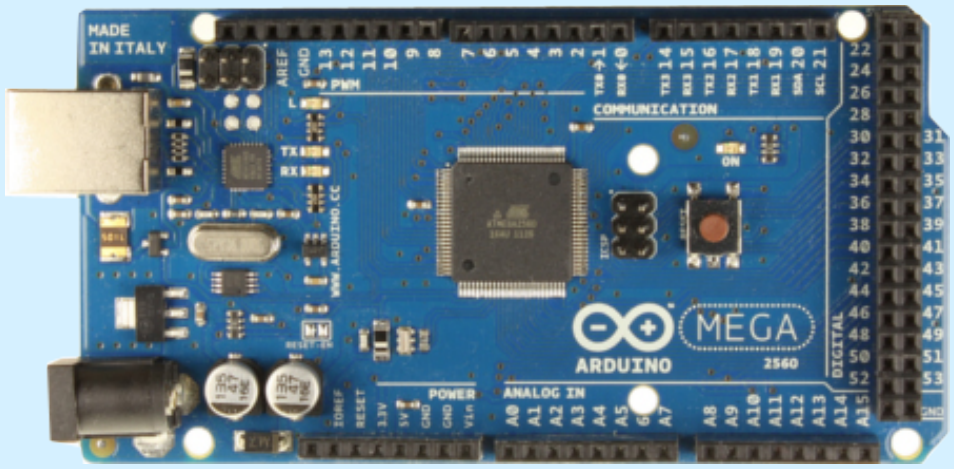
Arduino

- *Easy programming using Arduino studio*
- *No special programmer required*
- *Lots of I/O*
- *Standard libraries*
- *Low cost*



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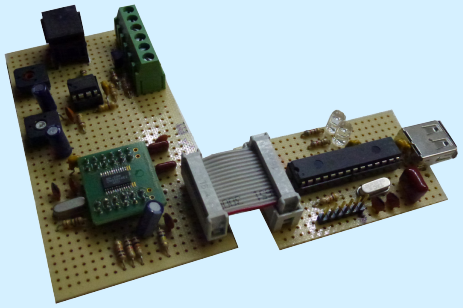
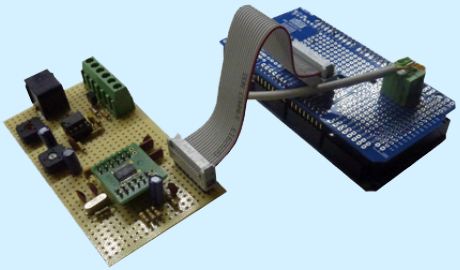
DVMEGA evolution

May 2013



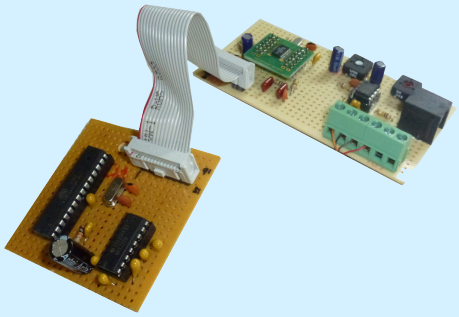
PIC based DV node
(GMSK modem for D-Star)

August 2013



Arduino based DV node

October 2013



ATMEGA328 based DV node

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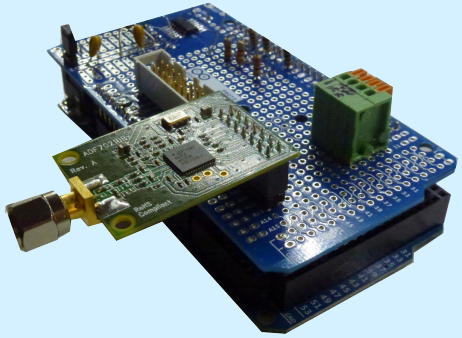
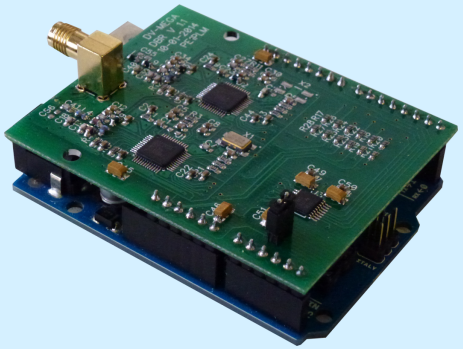
November 2013



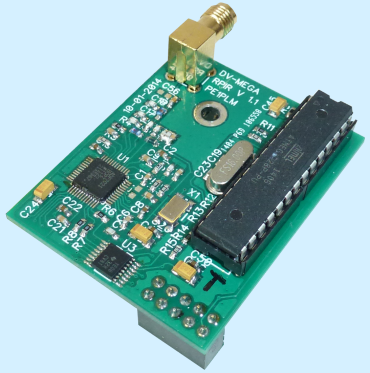
Arduino based radio hotspot

January 2014



Arduino based dualband radio hotspot

March 2014



ATMEGA328 based radio hotspot for Raspberry

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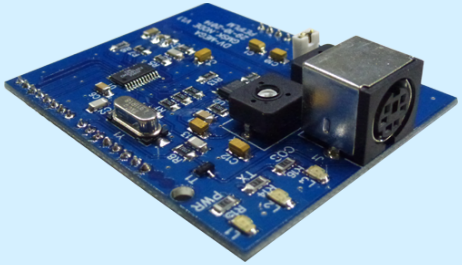
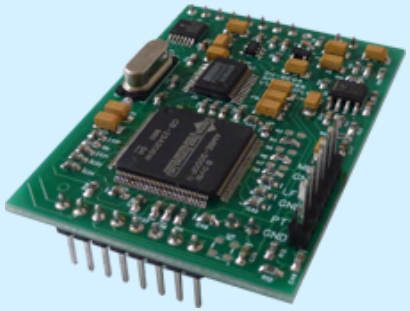
July 2014



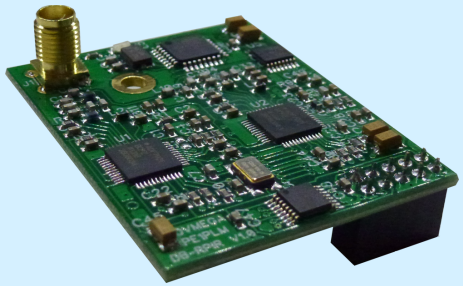
Arduino based DV node factory pcb

September 2014



Arduino based AMBE3000 codec/packet mode

December 2014



ATMEGA328 based dualband radio hotspot for Raspberry

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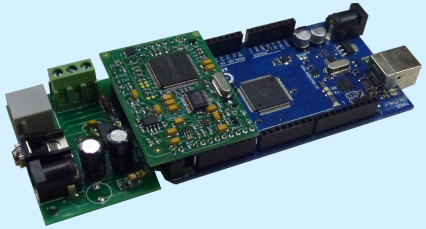
January 2015



Stand alone AMBE3000 dongle Drirect Voice Device

October 2015

DMR
DIGITAL MOBILE RADIO ASSOCIATION

DMR support added

September 2016

System Fusion

Fusion support added

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Development challenges

ATMEGA328 core specification

- *8 bit architecture*
- *16 Mhz speed*
- *32 kB Flash*
- *2 kB SRAM*
- *1 kB EEPROM*
- *2 external interrupts*

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Task list CPU

- *Radio server*
- *Serialport handler*
- *State machine*
- *Algorithm*
  - *Viterbi*
  - *Golay*
  - *Hamming*
  - *Block Product Turbo Code*
  - *Interleaving*
  - *CRC computation*

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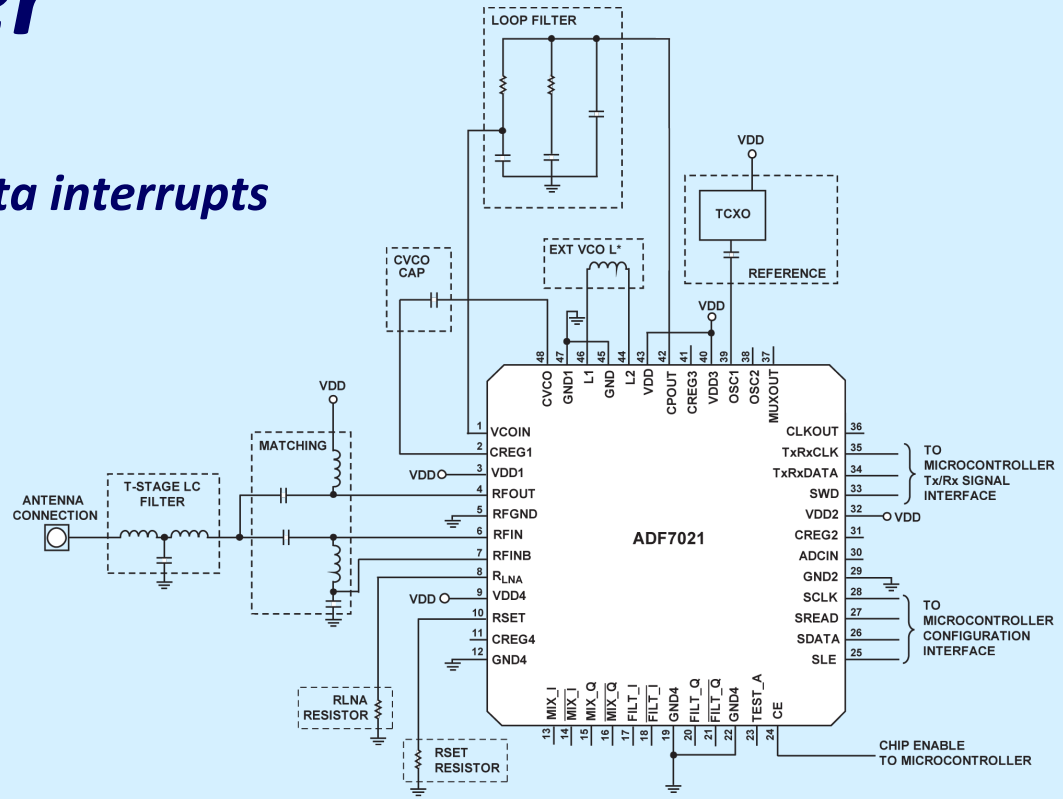
Radio server

- *Serve RX/TX radio data interrupts from ADF7021 radio*

- *Configuration of ADF7021 chip*



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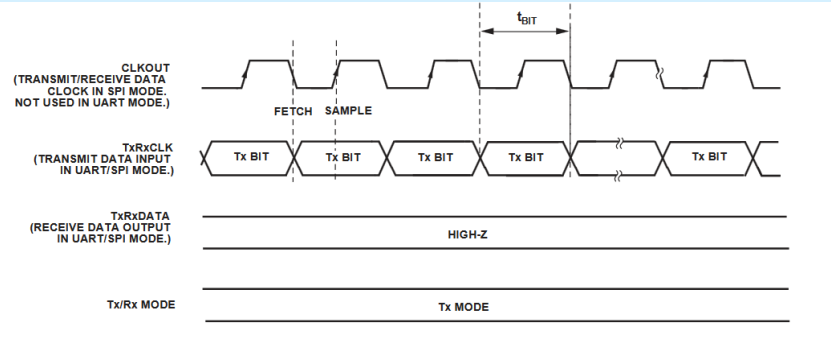
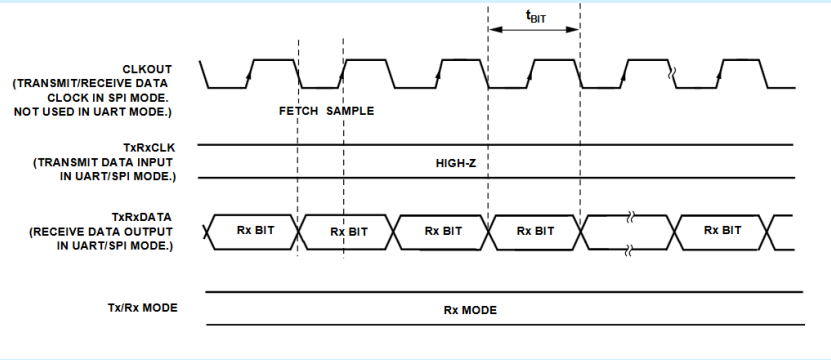
Serve radio TRX data interrupts

TX



RX



9600 INT per sec.

150 uS per INT

62,50 nS per instruction

2400 single clock instructions per INT

! Fusion and DMR = 9600 INT p/s for D-Star 4800 INT p/s

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Serialport handler

- *MMDVM protocol*
- *115200 baud, 8, N, 1*
- *Max 252 bytes payload*

Byte Number	Length (Bytes)	Value	Description
0	1	0xE0	Frame Start.
1	1	0x00 – 0xFF	Length. This value includes the Frame Start byte and all of the following data.
2	1	0x00 – 0xFF	Command or Response type.
3…	0..n		Data. The number of data bytes depends on the Command/Reponse byte.

Message

Byte Number	Length (Bytes)	Value	Description
0	1	0xE0	Frame Start.
1	1	4	Length.
2	1	0x03	Set Mode.
3	1	0 - 3	Modem State: 0 – Idle 1 – D-Star 2 – DMR 3 – System Fusion 99 - Calibration

Example of Set Mode

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DV protocol example

DMR as example
4FSK
4800 symb sec
9600 bits sec
TDMA 2 timeslots
2 x 2450 voice
2 x 1150 FEC
2 x 1200 embedded data

Information bits		Symbol	4FSK deviation
Bit 1	Bit 0		
0	1	+3	+1,944 kHz
0	0	+1	+0,648 kHz
1	0	-1	-0,648 kHz
1	1	-3	-1,944 kHz

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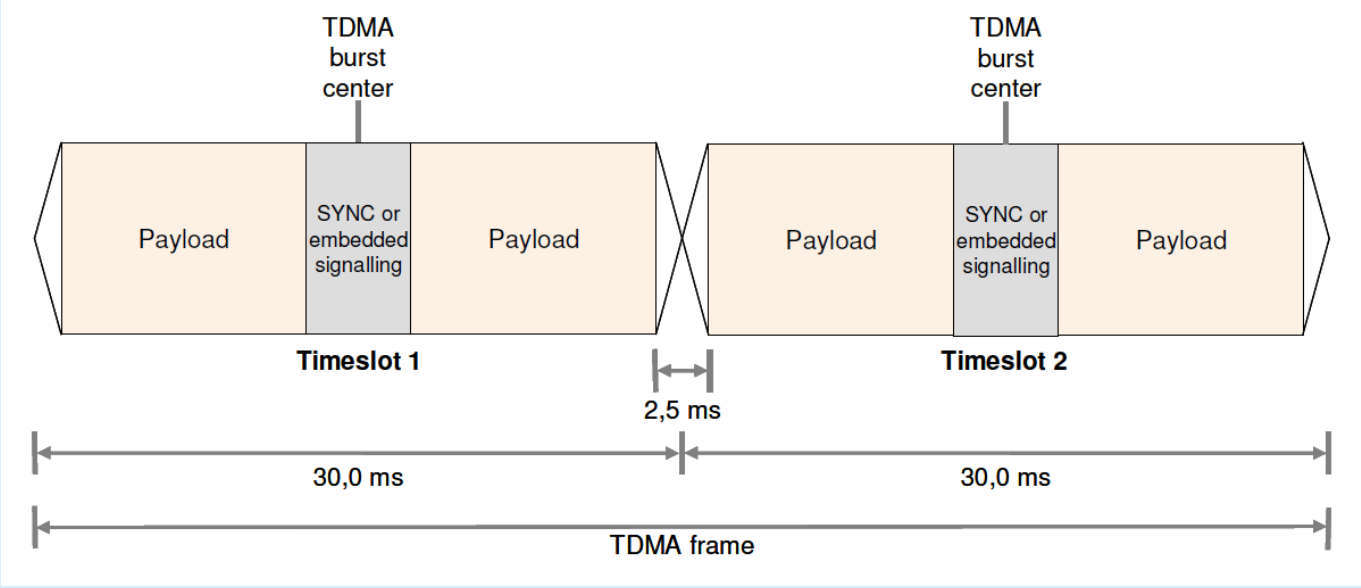
DMR TDMA burst



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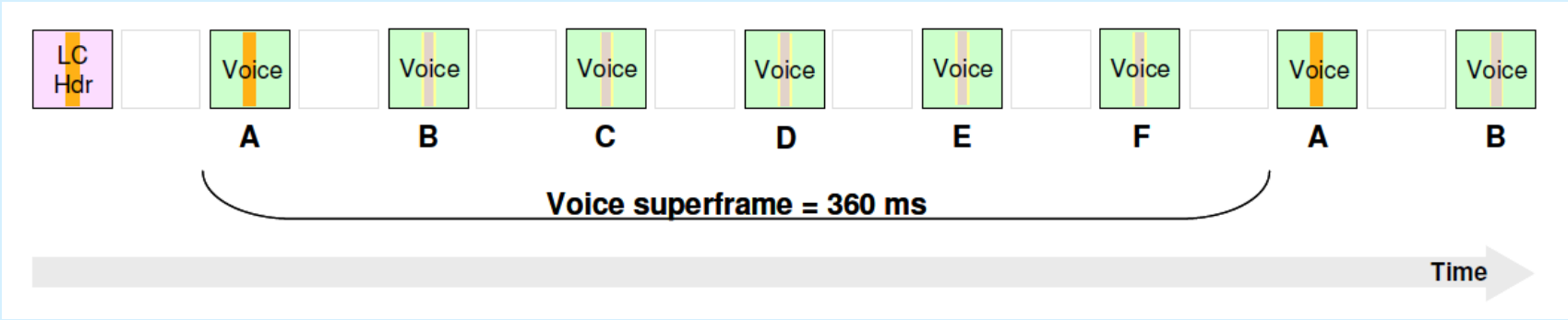
Voice initiation



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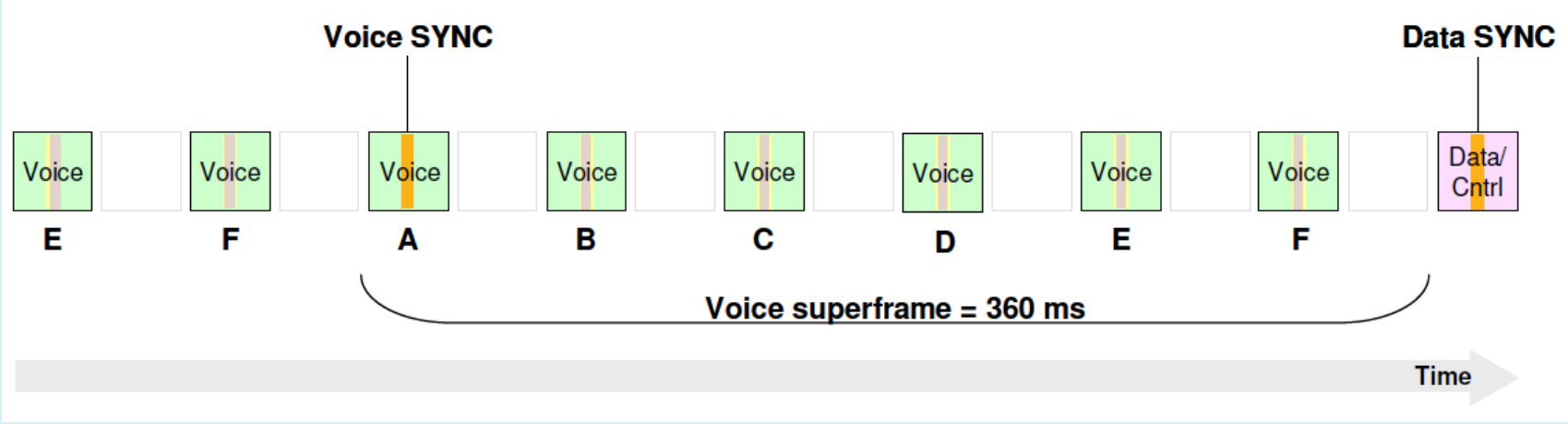
Voice terminator



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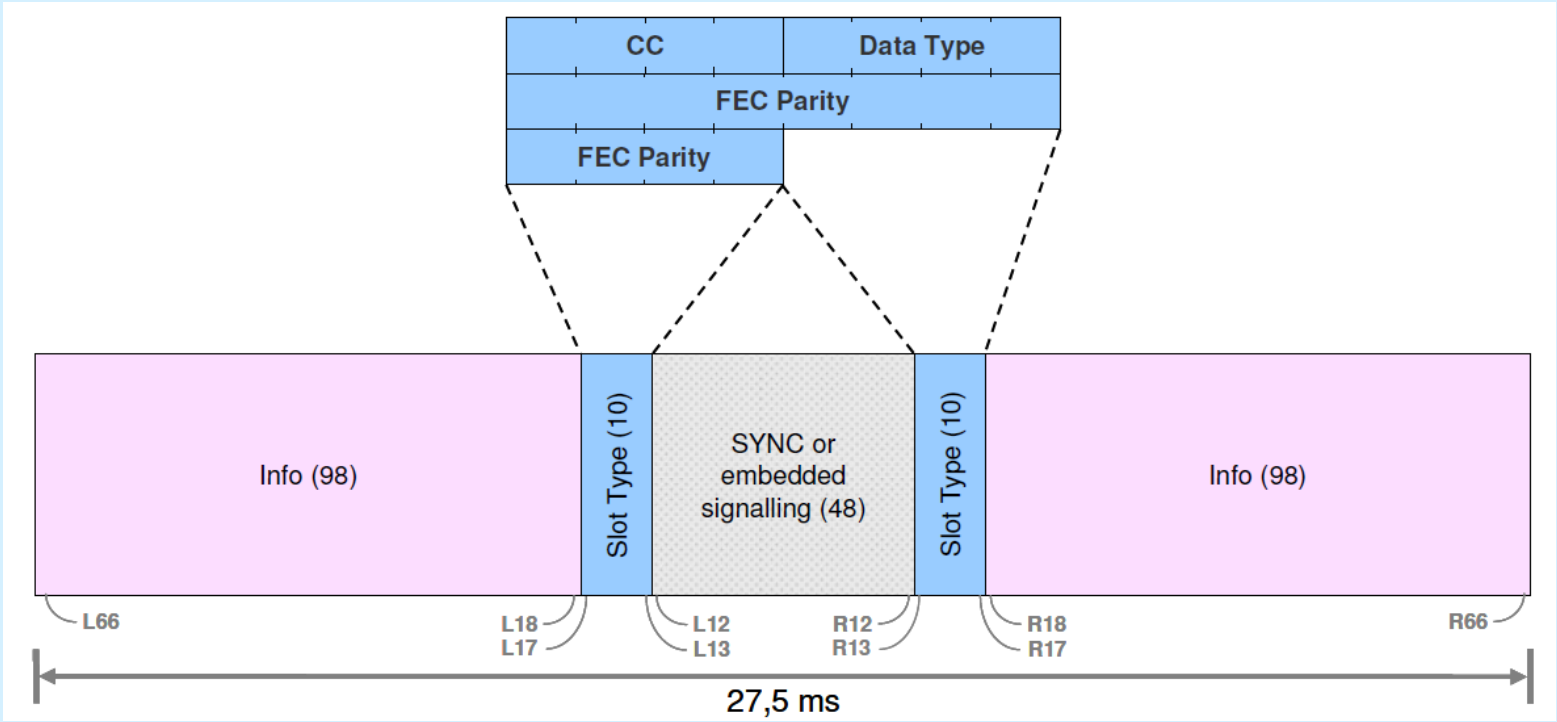
LC (Link Control) header



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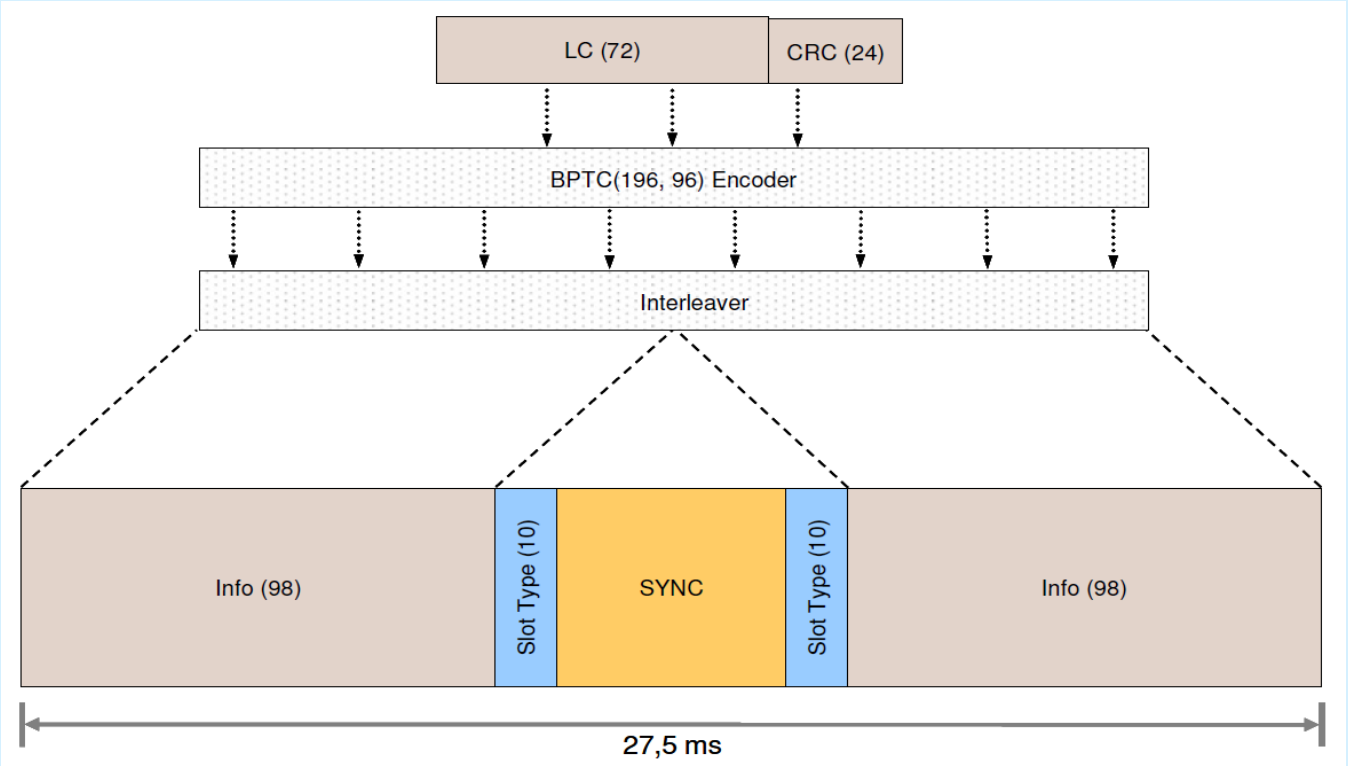
LC header data



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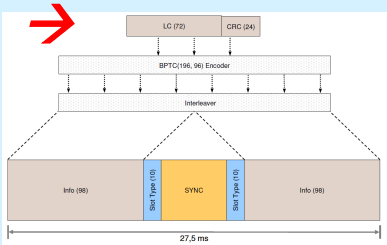
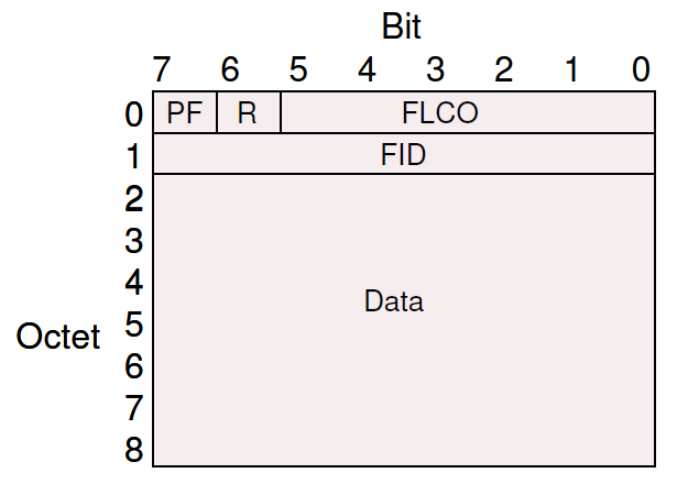
LC data





Information element	Length	Remark
Message dependent elements		
Protect Flag (PF)	1	
Reserved	1	This bit shall be set to 0_2
Feature elements		
Full Link Control Opcode (FLCO)	6	Shall be set to 000011_2
Feature set ID (FID)	8	Shall be set to 00000000_2
Service Options	8	
Target address	24	
Source address	24	

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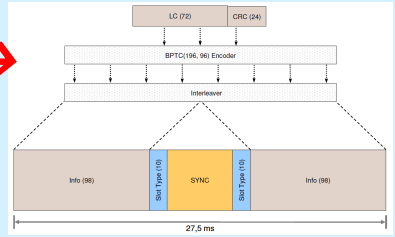
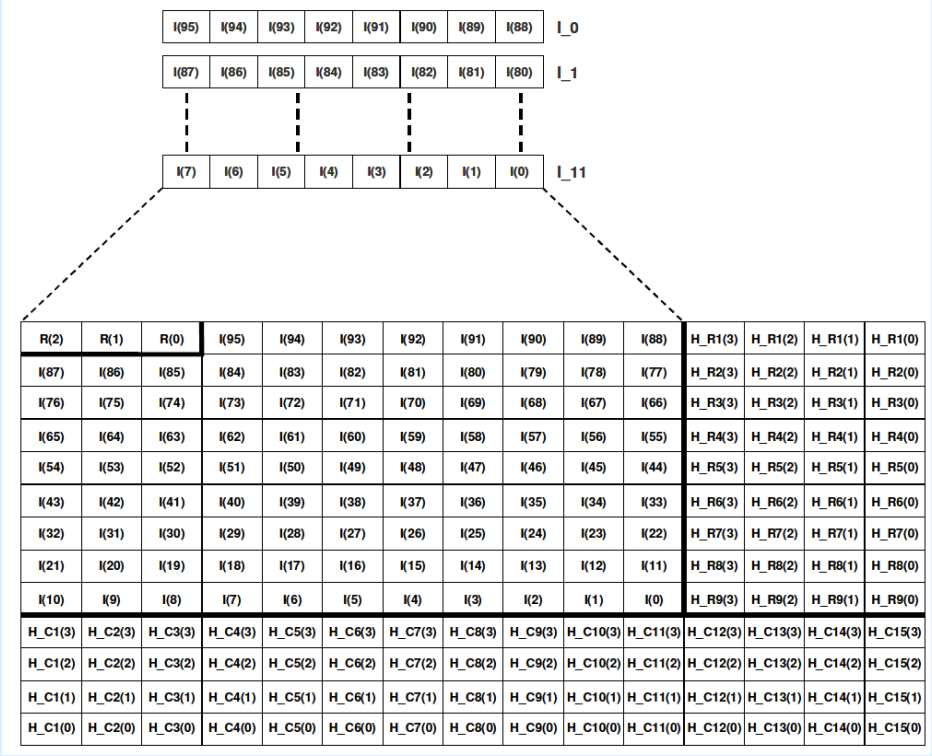
Block Turbo Product Code





R(2)	R(1)	R(0)	I(95)	I(94)	I(93)	I(92)	I(91)	I(90)	I(89)	I(88)	H_R1(3)	H_R1(2)	H_R1(1)	H_R1(0)
I(87)	I(86)	I(85)	I(84)	I(83)	I(82)	I(81)	I(80)	I(79)	I(78)	I(77)	H_R2(3)	H_R2(2)	H_R2(1)	H_R2(0)
I(76)	I(75)	I(74)	I(73)	I(72)	I(71)	I(70)	I(69)	I(68)	I(67)	I(66)	H_R3(3)	H_R3(2)	H_R3(1)	H_R3(0)
I(65)	I(64)	I(63)	I(62)	I(61)	I(60)	I(59)	I(58)	I(57)	I(56)	I(55)	H_R4(3)	H_R4(2)	H_R4(1)	H_R4(0)
I(54)	I(53)	I(52)	I(51)	I(50)	I(49)	I(48)	I(47)	I(46)	I(45)	I(44)	H_R5(3)	H_R5(2)	H_R5(1)	H_R5(0)
I(43)	I(42)	I(41)	I(40)	I(39)	I(38)	I(37)	I(36)	I(35)	I(34)	I(33)	H_R6(3)	H_R6(2)	H_R6(1)	H_R6(0)
I(32)	I(31)	I(30)	I(29)	I(28)	I(27)	I(26)	I(25)	I(24)	I(23)	I(22)	H_R7(3)	H_R7(2)	H_R7(1)	H_R7(0)
I(21)	I(20)	I(19)	I(18)	I(17)	I(16)	I(15)	I(14)	I(13)	I(12)	I(11)	H_R8(3)	H_R8(2)	H_R8(1)	H_R8(0)
I(10)	I(9)	I(8)	I(7)	I(6)	I(5)	I(4)	I(3)	I(2)	I(1)	I(0)	H_R9(3)	H_R9(2)	H_R9(1)	H_R9(0)
H_C1(3)	H_C2(3)	H_C3(3)	H_C4(3)	H_C5(3)	H_C6(3)	H_C7(3)	H_C8(3)	H_C9(3)	H_C10(3)	H_C11(3)	H_C12(3)	H_C13(3)	H_C14(3)	H_C15(3)
H_C1(2)	H_C2(2)	H_C3(2)	H_C4(2)	H_C5(2)	H_C6(2)	H_C7(2)	H_C8(2)	H_C9(2)	H_C10(2)	H_C11(2)	H_C12(2)	H_C13(2)	H_C14(2)	H_C15(2)
H_C1(1)	H_C2(1)	H_C3(1)	H_C4(1)	H_C5(1)	H_C6(1)	H_C7(1)	H_C8(1)	H_C9(1)	H_C10(1)	H_C11(1)	H_C12(1)	H_C13(1)	H_C14(1)	H_C15(1)
H_C1(0)	H_C2(0)	H_C3(0)	H_C4(0)	H_C5(0)	H_C6(0)	H_C7(0)	H_C8(0)	H_C9(0)	H_C10(0)	H_C11(0)	H_C12(0)	H_C13(0)	H_C14(0)	H_C15(0)

Calculate Hamming bits

- *Horizontal 15-11*
- *Vertical 13-9*

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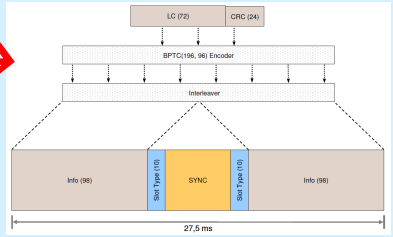
Block Turbo Product Code



R(2)	R(1)	R(0)	I(95)	I(94)	I(93)	I(92)	I(91)	I(90)	I(89)	I(88)	H_R1(3)	H_R1(2)	H_R1(1)	H_R1(0)

H_R1(3) = R(2) ^ R(1) ^ R(0) ^ I(95) ^ I(93) ^ I(91) ^ I(90)
H_R1(2) = R(1) ^ R(0) ^ I(95) ^ I(94) ^ I(92) ^ I(90) ^ I(89)
H_R1(1) = R(0) ^ I(95) ^ I(94) ^ I(93) ^ I(91) ^ I(89) ^ I(88)
H_R1(0) = R(2) ^ R(1) ^ R(0) ^ I(94) ^ I(93) ^ I(92) ^ I(88)

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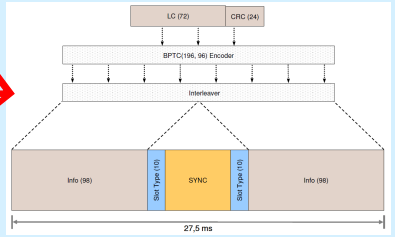
Interleaver

Bit Name	Index	Interleave Index
R(3)	0	0
R(2)	1	181
R(1)	2	166
R(0)	3	151
I(95)	4	136
I(94)	5	121
I(93)	6	106
I(92)	7	91
I(91)	8	76
I(90)	9	61
I(89)	10	46
I(88)	11	31
H_R1(3)	12	16
H_R1(2)	13	1
H_R1(1)	14	182
H_R1(0)	15	167
I(87)	16	152

Bit Name	Index	Interleave Index
R(3)	0	0
R(2)	1	181
R(1)	2	166
R(0)	3	151
I(95)	4	136
I(94)	5	121
I(93)	6	106
I(92)	7	91
I(91)	8	76
I(90)	9	61
I(89)	10	46
I(88)	11	31
H_R1(3)	12	16
H_R1(2)	13	1
H_R1(1)	14	182
H_R1(0)	15	167
I(87)	16	152
I(86)	17	137
I(85)	18	122
I(84)	19	107
I(83)	20	92
I(82)	21	77
I(81)	22	62
I(80)	23	47
I(79)	24	32
I(78)	25	17
I(77)	26	2
H_R2(3)	27	183
H_R2(2)	28	168
H_R2(1)	29	153
H_R2(0)	30	138
I(76)	31	123
I(75)	32	108
I(74)	33	93
I(73)	34	78
I(72)	35	63
I(71)	36	48
I(70)	37	33
I(69)	38	18
I(68)	39	3
I(67)	40	184
I(66)	41	169
H_R3(3)	42	154
H_R3(2)	43	139
H_R3(1)	44	124
H_R3(0)	45	109
I(65)	46	94
I(64)	47	79
I(63)	48	64
I(62)	49	49
I(61)	50	34
I(60)	51	19
I(59)	52	4
I(58)	53	185
I(57)	54	170
I(56)	55	155
I(55)	56	140
H_R4(3)	57	125
H_R4(2)	58	110
H_R4(1)	59	95
H_R4(0)	60	80
I(54)	61	65
I(53)	62	50
I(52)	63	35
I(51)	64	20
I(50)	65	5

Bit Name	Index	Interleave Index
I(49)	66	186
I(48)	67	171
I(47)	68	156
I(46)	69	141
I(45)	70	126
I(44)	71	111
H_R5(3)	72	96
H_R5(2)	73	81
H_R5(1)	74	66
H_R5(0)	75	51
I(43)	76	36
I(42)	77	21
I(41)	78	6
I(40)	79	187
I(39)	80	172
I(38)	81	157
I(37)	82	142
I(36)	83	127
I(35)	84	112
I(34)	85	97
I(33)	86	82
H_R6(3)	87	67
H_R6(2)	88	52
H_R6(1)	89	37
H_R6(0)	90	22
I(32)	91	7
I(31)	92	188
I(30)	93	173
I(29)	94	158
I(28)	95	143
I(27)	96	128
I(26)	97	113
I(25)	98	98
I(24)	99	83
I(23)	100	68
I(22)	101	53
H_R7(3)	102	38
H_R7(2)	103	23
H_R7(1)	104	8
H_R7(0)	105	189
I(21)	106	174
I(20)	107	159
I(19)	108	144
I(18)	109	129
I(17)	110	114
I(16)	111	99
I(15)	112	84
I(14)	113	69
I(13)	114	54
I(12)	115	39
I(11)	116	24
H_R8(3)	117	9
H_R8(2)	118	190
H_R8(1)	119	175
H_R8(0)	120	160
I(10)	121	145
I(9)	122	130
I(8)	123	115
I(7)	124	100
I(6)	125	85
I(5)	126	70
I(4)	127	55
I(3)	128	40
I(2)	129	25
I(1)	130	10
I(0)	131	191

Bit Name	Index	Interleave Index
H_R9(3)	132	176
H_R9(2)	133	161
H_R9(1)	134	146
H_R9(0)	135	131
H_C1(3)	136	116
H_C2(3)	137	101
H_C3(3)	138	86
H_C4(3)	139	71
H_C5(3)	140	56
H_C6(3)	141	41
H_C7(3)	142	26
H_C8(3)	143	11
H_C9(3)	144	192
H_C10(3)	145	177
H_C11(3)	146	162
H_C12(3)	147	147
H_C13(3)	148	132
H_C14(3)	149	117
H_C15(3)	150	102
H_C1(2)	151	87
H_C2(2)	152	72
H_C3(2)	153	57
H_C4(2)	154	42
H_C5(2)	155	27
H_C6(2)	156	12
H_C7(2)	157	193
H_C8(2)	158	178
H_C9(2)	159	163
H_C10(2)	160	148
H_C11(2)	161	133
H_C12(2)	162	118
H_C13(2)	163	103
H_C14(2)	164	88
H_C15(2)	165	73
H_C1(1)	166	58
H_C2(1)	167	43
H_C3(1)	168	28
H_C4(1)	169	13
H_C5(1)	170	194
H_C6(1)	171	179
H_C7(1)	172	164
H_C8(1)	173	149
H_C9(1)	174	134
H_C10(1)	175	119
H_C11(1)	176	104
H_C12(1)	177	89
H_C13(1)	178	74
H_C14(1)	179	59
H_C15(1)	180	44
H_C1(0)	181	29
H_C2(0)	182	14
H_C3(0)	183	195
H_C4(0)	184	180
H_C5(0)	185	165
H_C6(0)	186	150
H_C7(0)	187	135
H_C8(0)	188	120
H_C9(0)	189	105
H_C10(0)	190	90
H_C11(0)	191	75
H_C12(0)	192	60
H_C13(0)	193	45
H_C14(0)	194	30
H_C15(0)	195	15



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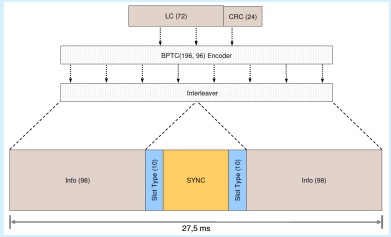
Radio voice header

Symbol	Bit 1	Bit 0	Symbol	Bit 1	Bit 0	Symbol	Bit 1	Bit 0
L66	R(3)	H_R1(2)	L22	H_C14(2)	H_C12(1)	R23	I(75)	H_R3(0)
L65	I(77)	I(68)	L21	H_C10(0)	I(92)	R24	H_R4(2)	I(44)
L64	I(59)	I(50)	L20	I(83)	I(74)	R25	I(35)	I(26)
L63	I(41)	I(32)	L19	I(65)	H_R4(1)	R26	I(17)	I(8)
L62	H_R7(1)	H_R8(3)	L18	H_R5(3)	I(34)	R27	H_C1(3)	H_C14(3)
L61	I(1)	H_C8(3)	L17	CC(3)	CC(2)	R28	H_C12(2)	H_C10(1)
L60	H_C6(2)	H_C4(1)	L16	CC(1)	CC(0)	R29	H_C8(0)	I(94)
L59	H_C2(0)	H_C15(0)	L15	DT (3)	DT (2)	R30	I(85)	I(76)
L58	H_R1(3)	I(78)	L14	DT (1)	DT (0)	R31	H_R3(1)	H_R4(3)
L57	I(69)	I(60)	L13	Golay(11)	Golay(10)	R32	I(45)	I(36)
L56	I(51)	I(42)	L12	D_Sync(47)	D_Sync(46)	R33	I(27)	I(18)
L55	H_R6(0)	H_R7(2)	L11	D_Sync(45)	D_Sync(44)	R34	I(9)	H_R9(0)
L54	I(11)	I(2)	L10	D_Sync(43)	D_Sync(42)	R35	H_C13(3)	H_C11(2)
L53	H_C7(3)	H_C5(2)	L9	D_Sync(41)	D_Sync(40)	R36	H_C9(1)	H_C7(0)
L52	H_C3(1)	H_C1(0)	L8	D_Sync(39)	D_Sync(38)	R37	I(95)	I(86)
L51	H_C14(0)	I(88)	L7	D_Sync(37)	D_Sync(36)	R38	H_R2(0)	H_R3(2)
L50	I(79)	I(70)	L6	D_Sync(35)	D_Sync(34)	R39	I(55)	I(46)
L49	I(61)	I(52)	L5	D_Sync(33)	D_Sync(32)	R40	I(37)	I(28)
L48	I(43)	H_R6(1)	L4	D_Sync(31)	D_Sync(30)	R41	I(19)	I(10)
L47	H_R7(3)	I(12)	L3	D_Sync(29)	D_Sync(28)	R42	H_R9(1)	H_C12(3)
L46	I(3)	H_C6(3)	L2	D_Sync(27)	D_Sync(26)	R43	H_C10(2)	H_C8(1)
L45	H_C4(2)	H_C2(1)	L1	D_Sync(25)	D_Sync(24)	R44	H_C6(0)	R(0)
L44	H_C15(1)	H_C13(0)	R1	D_Sync(23)	D_Sync(22)	R45	I(87)	H_R2(1)
L43	I(89)	I(80)	R2	D_Sync(21)	D_Sync(20)	R46	H_R3(3)	I(56)
L42	I(71)	I(62)	R3	D_Sync(19)	D_Sync(18)	R47	I(47)	I(38)
L41	I(53)	H_R5(0)	R4	D_Sync(17)	D_Sync(16)	R48	I(29)	I(20)
L40	H_R6(2)	I(22)	R5	D_Sync(15)	D_Sync(14)	R49	H_R8(0)	H_R9(2)
L39	I(13)	I(4)	R6	D_Sync(13)	D_Sync(12)	R50	H_C11(3)	H_C9(2)
L38	H_C5(3)	H_C3(2)	R7	D_Sync(11)	D_Sync(10)	R51	H_C7(1)	H_C5(0)
L37	H_C1(1)	H_C14(1)	R8	D_Sync(9)	D_Sync(8)	R52	R(1)	H_R1(0)
L36	H_C12(0)	I(90)	R9	D_Sync(7)	D_Sync(6)	R53	H_R2(2)	I(66)
L35	I(81)	I(72)	R10	D_Sync(5)	D_Sync(4)	R54	I(57)	I(48)
L34	I(63)	I(54)	R11	D_Sync(3)	D_Sync(2)	R55	I(39)	I(30)
L33	H_R5(1)	H_R6(3)	R12	D_Sync(1)	D_Sync(0)	R56	I(21)	H_R8(1)
L32	I(23)	I(14)	R13	Golay(9)	Golay(8)	R57	H_R9(3)	H_C10(3)
L31	I(5)	H_C4(3)	R14	Golay(7)	Golay(6)	R58	H_C8(2)	H_C6(1)
L30	H_C2(2)	H_C15(2)	R15	Golay(5)	Golay(4)	R59	H_C4(0)	R(2)
L29	H_C13(1)	H_C11(0)	R16	Golay(3)	Golay(2)	R60	H_R1(1)	H_R2(3)
L28	I(91)	I(82)	R17	Golay(1)	Golay(0)	R61	I(67)	I(58)
L27	I(73)	I(64)	R18	I(25)	I(16)	R62	I(49)	I(40)
L26	H_R4(0)	H_R5(2)	R19	I(7)	H_C2(3)	R63	I(31)	H_R7(0)
L25	I(33)	I(24)	R20	H_C15(3)	H_C13(2)	R64	H_R8(2)	I(0)
L24	I(15)	I(6)	R21	H_C11(1)	H_C9(0)	R65	H_C9(3)	H_C7(2)
L23	H_C3(3)	H_C1(2)	R22	I(93)	I(84)	R66	H_C5(1)	H_C3(0)



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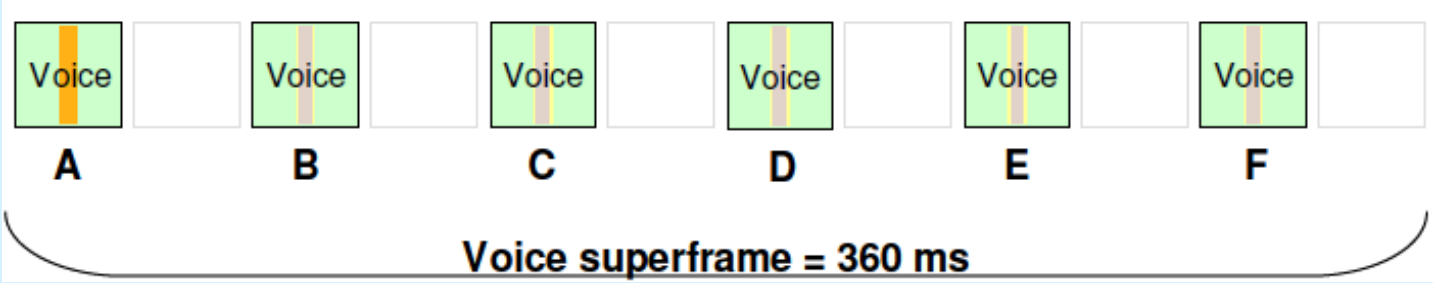
Voice superframe



A = 216 bit voice and 48 bits sync

B..F = 216 bits voice and 48 bits embedded signaling

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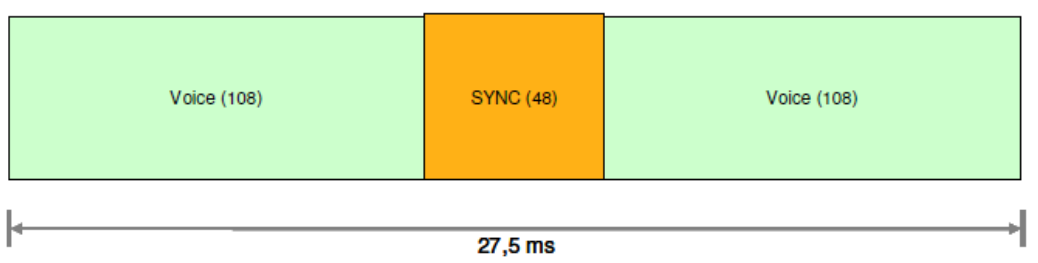
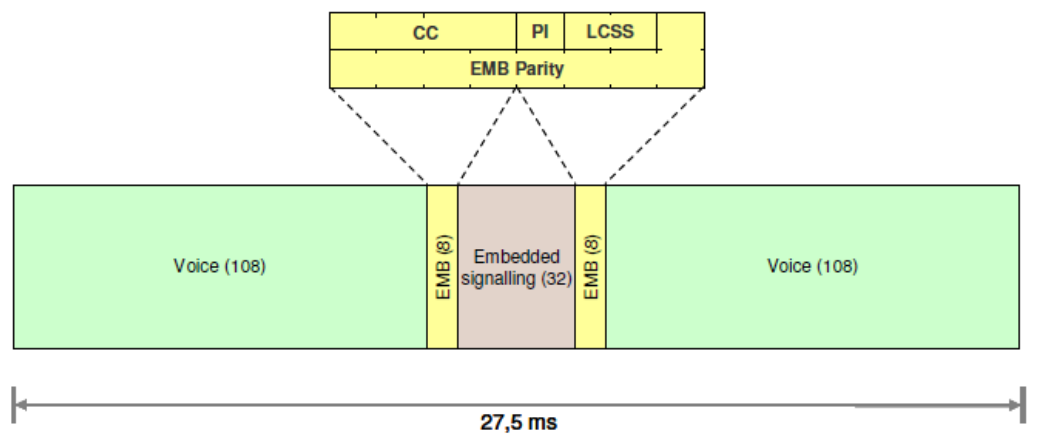
Embedded signaling



Frame A
- Syncword



Frame B..F
- EMB
- Embedded signaling

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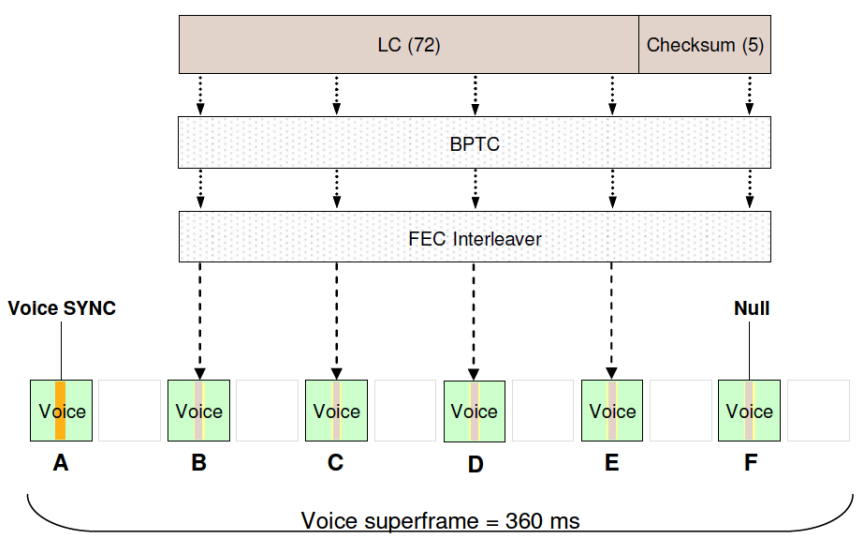
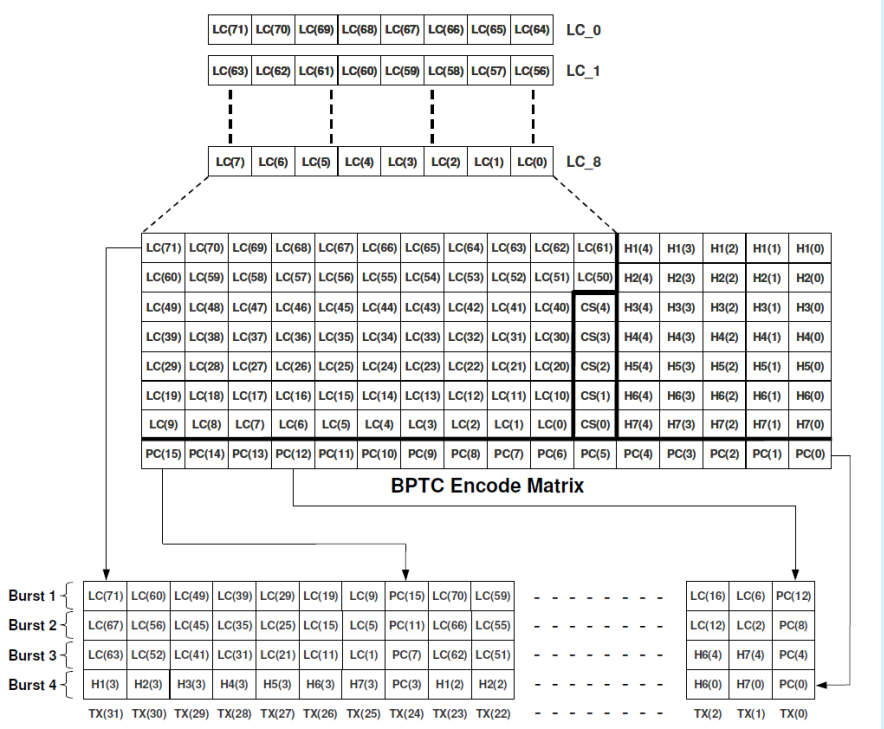
Embedded signaling





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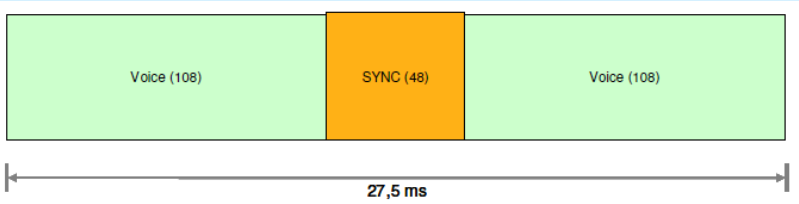
Voice



- ***Voice has no additional FEC or interleaving***
- ***System use AMBE's data protection and FEC***

Symbol	Bit 1	Bit 0	Symbol	Bit 1	Bit 0	Symbol	Bit 1	Bit 0
L66	VS(215)	VS(214)	L22	VS(127)	VS(126)	R23	VS(87)	VS(86)
L65	VS(213)	VS(212)	L21	VS(125)	VS(124)	R24	VS(85)	VS(84)
L64	VS(211)	VS(210)	L20	VS(123)	VS(122)	R25	VS(83)	VS(82)
L63	VS(209)	VS(208)	L19	VS(121)	VS(120)	R26	VS(81)	VS(80)
L62	VS(207)	VS(206)	L18	VS(119)	VS(118)	R27	VS(79)	VS(78)
L61	VS(205)	VS(204)	L17	VS(117)	VS(116)	R28	VS(77)	VS(76)
L60	VS(203)	VS(202)	L16	VS(115)	VS(114)	R29	VS(75)	VS(74)
L59	VS(201)	VS(200)	L15	VS(113)	VS(112)	R30	VS(73)	VS(72)
L58	VS(199)	VS(198)	L14	VS(111)	VS(110)	R31	VS(71)	VS(70)
L57	VS(197)	VS(196)	L13	VS(109)	VS(108)	R32	VS(69)	VS(68)
L56	VS(195)	VS(194)	L12	V_Sync(47)	V_Sync(46)	R33	VS(67)	VS(66)
L55	VS(193)	VS(192)	L11	V_Sync(45)	V_Sync(44)	R34	VS(65)	VS(64)
L54	VS(191)	VS(190)	L10	V_Sync(43)	V_Sync(42)	R35	VS(63)	VS(62)
L53	VS(189)	VS(188)	L9	V_Sync(41)	V_Sync(40)	R36	VS(61)	VS(60)
L52	VS(187)	VS(186)	L8	V_Sync(39)	V_Sync(38)	R37	VS(59)	VS(58)
L51	VS(185)	VS(184)	L7	V_Sync(37)	V_Sync(36)	R38	VS(57)	VS(56)
L50	VS(183)	VS(182)	L6	V_Sync(35)	V_Sync(34)	R39	VS(55)	VS(54)
L49	VS(181)	VS(180)	L5	V_Sync(33)	V_Sync(32)	R40	VS(53)	VS(52)
L48	VS(179)	VS(178)	L4	V_Sync(31)	V_Sync(30)	R41	VS(51)	VS(50)
L47	VS(177)	VS(176)	L3	V_Sync(29)	V_Sync(28)	R42	VS(49)	VS(48)
L46	VS(175)	VS(174)	L2	V_Sync(27)	V_Sync(26)	R43	VS(47)	VS(46)
L45	VS(173)	VS(172)	L1	V_Sync(25)	V_Sync(24)	R44	VS(45)	VS(44)
L44	VS(171)	VS(170)	R1	V_Sync(23)	V_Sync(22)	R45	VS(43)	VS(42)
L43	VS(169)	VS(168)	R2	V_Sync(21)	V_Sync(20)	R46	VS(41)	VS(40)
L42	VS(167)	VS(166)	R3	V_Sync(19)	V_Sync(18)	R47	VS(39)	VS(38)
L41	VS(165)	VS(164)	R4	V_Sync(17)	V_Sync(16)	R48	VS(37)	VS(36)
L40	VS(163)	VS(162)	R5	V_Sync(15)	V_Sync(14)	R49	VS(35)	VS(34)
L39	VS(161)	VS(160)	R6	V_Sync(13)	V_Sync(12)	R50	VS(33)	VS(32)
L38	VS(159)	VS(158)	R7	V_Sync(11)	V_Sync(10)	R51	VS(31)	VS(30)
L37	VS(157)	VS(156)	R8	V_Sync(9)	V_Sync(8)	R52	VS(29)	VS(28)
L36	VS(155)	VS(154)	R9	V_Sync(7)	V_Sync(6)	R53	VS(27)	VS(26)
L35	VS(153)	VS(152)	R10	V_Sync(5)	V_Sync(4)	R54	VS(25)	VS(24)
L34	VS(151)	VS(150)	R11	V_Sync(3)	V_Sync(2)	R55	VS(23)	VS(22)
L33	VS(149)	VS(148)	R12	V_Sync(1)	V_Sync(0)	R56	VS(21)	VS(20)
L32	VS(147)	VS(146)	R13	VS(107)	VS(106)	R57	VS(19)	VS(18)
L31	VS(145)	VS(144)	R14	VS(105)	VS(104)	R58	VS(17)	VS(16)
L30	VS(143)	VS(142)	R15	VS(103)	VS(102)	R59	VS(15)	VS(14)
L29	VS(141)	VS(140)	R16	VS(101)	VS(100)	R60	VS(13)	VS(12)
L28	VS(139)	VS(138)	R17	VS(99)	VS(98)	R61	VS(11)	VS(10)
L27	VS(137)	VS(136)	R18	VS(97)	VS(96)	R62	VS(9)	VS(8)
L26	VS(135)	VS(134)	R19	VS(95)	VS(94)	R63	VS(7)	VS(6)
L25	VS(133)	VS(132)	R20	VS(93)	VS(92)	R64	VS(5)	VS(4)
L24	VS(131)	VS(130)	R21	VS(91)	VS(90)	R65	VS(3)	VS(2)
L23	VS(129)	VS(128)	R22	VS(89)	VS(88)	R66	VS(1)	VS(0)

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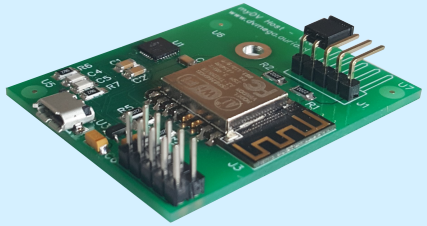
Under development

- *DVMEGA Dongle,* *use D-Star, DMR and Fusion digital networks with only a AMBE3000 and host integrated mice and speaker.*

- *DVMEGA Cast,* *direct connect to D-Star, DMR or Fusion digital networks using standard mice and speaker.*

- *DVMEGA Handy,* *handheld WIFI device with integrated host to connect D-Star, DMR or Fusion networks direct.*



-*DVMEGA Host,* *stand-alone DV host based on ESP32*

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Made in the Netherlands