CCITT SGXV
Working Party XV/1
Specialists Group on Coding for Visual Telephony

Document #510
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Title : PSC / GBSC Emulation problem
Source: Japan

1. Introduction

In this document, PSC or GBSC emulation is investigated based on the Specification for Flexible Hardware in Appendix 4 to Doc. #499R.

2. Summary of Investigation Results

Investigation details are shown in Appendix 1. to this document. There are 18 cases in which more than 15 consecutive "0"s can occur.

<Macroblock Layer>

Case 1: MVDy=12 & CBP=60 & TCOEFF={Group(+8)}
(the MB is "MC coded" or "MC coded + Q")
"0000 0100 000, 000, 0000 0000 1sss ss" (16)

Case 2: Q=16 & CBP=60 & TCOEFF={Group(+8)}
(the MB is "INTER coded + Q")
"1 0000, 000, 0000 0000 1sss ss" (15)

Group(+8) consists of the TCOEFF code words each of which has eight consecutive 0s in the left hand side. Group(+8) includes following codes:

[RUN = 0 & 11< |LEVEL| <16],
[RUN = 1 & |LEVEL| = 6,7],
[RUN = 2 & |LEVEL| = 5],
[RUN = 3 & |LEVEL| = 4],
[RUN = 5 & |LEVEL| = 3],
[RUN = 9,10 & |LEVEL| = 2],
[21< RUN <27 & |LEVEL| = 1].

<Group of Block Layer>

Case 3: GEI=1 & GSPARE=0 & MBA=STUFF
"1, 0000 0000 0000 0000, 0000 0001 111" (23)

Case 4: EOB & GBSC (the former MB is not "MC not coded")
"10, 0000 0000 0000 0001" (16)

Case 5: MVDy=12 & GBSC (the former MB is "MC not coded")
"0000 0100 000, 0000 0000 0000 0001" (20)

<Picture Layer>

Case 6: PSC & TR=0 & TYPE1=0 & PEI1=0 & PEI2=0 & GBSC
"0000 0000 0000 0001 0000, 0 0000, 0 0000 0000 0000, 0, 0, 0000 0000 0000 0001" (39)

Case 7: PSC & TR=0 & TYPE1=0 & PEI1=0 & PEI2=1
"0000 0000 0000 0001 0000, 0 0000, 0 0000 0000 0000, 0, 1" (23)

Case 8: PSC & TR=0 & TYPE1=0 & PEI1=1
"0000 0000 0000 0001 0000, 0 0000, 0 0000 0000 0000, 1" (22)

Case 9: PSC & TR=0 & TYPE1=1
"0000 0000 0000 0001 0000, 0 0000, 0 0000 0000 0001" (21)

Case 10: TR=16 & TYPE1=0 & PEI1=0 & PEI2=0 & GBSC
"1 0000, 0 0000 0000 0000, 0, 0, 0000 0000 0000 0001" (34)

Case 11: TR=16 & TYPE1=0 & PEI1=0 & PEI2=1
"1 0000, 0 0000 0000 0000, 0, 1" (18)

Case 12: TR=16 & TYPE1=0 & PEI1=1
"1 0000, 0 0000 0000 0000, 1" (17)

Case 13: TR=16 & TYPE1=1
"1 0000, 0 0000 0000 0001" (16)

Case 14: TYPE1=0x1000 & PEI1=0 & PEI2=0 & GBSC
"1 0000 0000 0000, 0, 0, 0000 0000 0000 0001" (29)

Case 15: PEI1=1 & PARITY=0 & PEI2=0 & GBSC
"1, 0000 0000, 0, 0000 0000 0000 0001" (24)

Case 16: PEI2=1 & PSPARE=0 & GBSC
"1, 0000 0000 0000 0000, 0000 0000 0000 0001" (31)

Case 17: EOB & PSC (the former MB is not "MC not coded")
"10, 0000 0000 0000 0001 0000" (16)

Case 18: MVDy=12 & PSC (the former MB is "MC not coded")
"0000 0100 000, 0000 0000 0000 0001 0000" (20)

In Cases 4, 5, 6, 10, 14, 15 and 16, GBSC can be caught. In Cases 17 and 18, PSC can be caught. Cases 3, 7, 8, 9, 11, 12 and 13 relate to GOB or Picture headers, therefore emulation can be avoided. On the other hand, both Cases 1 and 2 have no relation to either GOB or Picture headers, so they may cause the emulation problems. The emulation can be prevented by modifying the CBP code words, especially by removing "000" (CBP=60). Appendix 2 to this document shows one such example code table for CBP.

3. Conclusion

The GBSC or PSC emulation problem is investigated. There are two cases causing emulation:

Case 1: MVDy=12 & CBP=60 & TCOEFF={Group(+8)}
(the MB is "MC coded" or "MC coded + Q")
"0000 0100 000, 000, 0000 0000 1sss ss" (16)

Case 2: Q=16 & CBP=60 & TCOEFF={Group(+8)}
(the MB is "INTER coded + Q")
"1 0000, 000, 0000 0000 1sss ss" (15)

The emulation can be prevented by modifying the CBP code words. Therefore, this document proposes modification of the CBP code table.

4. Appendix

Appendix 1: Detail results of emulation investigation
Appendix 2: Example code table for CBP

END.

Appendix 1 to Doc. #510

Detail results of emulation investigation

<Block Layer>

TCOEFF code words with long consecutive 0s in the left-hand side, right-hand side or inside are:

"0000 0100 0000 0001 ssss" (9)	: [RUN=0 & 15<LEVEL<32]
"0000 0000 1sss ss" (+8)	: [RUN=0 & 11<|LEVEL|<16]
	,[RUN=1 & |LEVEL|=6,7]
	,[RUN=2 & |LEVEL|=5]
	,[RUN=3 & |LEVEL|=4]
	,[RUN=5 & |LEVEL|=3]
	,[RUN=9,10 & |LEVEL|=2]
	,[21<RUN<27 & |LEVEL|=1]
(Afterwards these codes are called as Group(+8))	
"0010 0000 0" (6+)	: [RUN=13 & LEVEL=1]
"0000 01ss ssss s100 0000" (6+)	: [RUN=* & |LEVEL|=64]
(Afterwards these two type codes are called as Group(6+))	

INTRA DC code words with long consecutive 0s are:

"0000 0001" (+7)	: DC=1
"s100 0000" (6+)	: DC=64,192

EOB code is "10" (1+).

In connecting these code words to form a block data, the maximum lengths of consecutive 0s in the left-hand side, junction parts and the right-hand side are as follows.

[TCOEFF x n + EOB] case

Left-hand	: +8	(TCOEFF={Group(+8)})
Junction	: 14	(TCOEFF={Group(6+)} & TCOEFF={Group(+8)})
Right-hand	: 1+	(EOB)

[DC + TCOEFF x n + EOB] case

Left-hand	: +7	(DC=1)
Junction	: 14	(DC=64,192 & TCOEFF={Group(+8)})
	14	(TCOEFF={Group(6+)} & TCOEFF={Group(+8)})
Right-hand	: 1+	(EOB)

Furthermore, in connecting these block data to form multi-blocks data, the maximum lengths of consecutive 0s are as follows.

[(TCOEFF x n + EOB) x m] case (INTER Block data)

Left-hand	: +8	(TCOEFF={Group(+8)})
Junction	: 9	(EOB & TCOEFF={Group(+8)})
Right-hand	: 1+	(EOB)

[(DC + TCOEFF x n + EOB) x m] case (INTRA Block data)

Left-hand	: +7	(DC=1)
Junction	: 8	(EOB & DC=1)
Right-hand	: 1+	(EOB)

<Macroblock Layer>

MBA code words with long consecutive 0s:

"0000 0001 111, *" (+7)	: MBA=STUFF + *
"0000 0011 sss" (+6)	: MBA=26 to 33
"0000 0001 111, 0000 0001 111, *" (7)	: MBA=STUFF + STUFF + *
"0000 0100 000" (5+)	: MBA=25
"0000 0001 111, 0000 0100 000" (5+)	: MBA=STUFF x n + 25

QUANT2 code words with long consecutive 0s:

"0000 1" (+4)	: Q=1
"1000 0" (4+)	: Q=16

MVD code words with long consecutive 0s:

"0000 0011 ppp, *" (+6)	: |MVDx|>12 & MVDy=*
"*, 0000 0100 000" (5+)	: MVDx=* & MVDy=12
"0000 0100 000, 0000 0011 ppp" (11) ("ppp"= "1ss","01s","001")	: MVDx=12 & |MVDy|>12

CBP code words with long consecutive 0s:

"000" (+3+)	: CBP=60 (Yall)
"1110 0000" (5+)	: CBP=7 (Y4+CB+CR)

If a macroblock is "INTER coded", TYPE3="1", then the maximum lengths of consecutive 0s in [MBA+TYPE3+CBP+(INTER Block data)] are as follows.

Left	: +7	(MBA=STUFF+*)
Junction:	5	(MBA=25 & TYPE3)
	11	(TYPE3 & CBP=60 & TCOEFF={Group(+8)})
Right	: 1+	(EOB)

If a macroblock is "MC coded", TYPE3="01", then the maximum lengths of consecutive 0s in [MBA+TYPE3+MVD+CBP+(INTER Block data)] are as follows.

Left	: +7	(MBA=STUFF+*)
Junction:	6	(MBA=25 & TYPE3)
	6	(TYPE3 & |MVDx|>12)
	16	(MVDy=12 & CBP=60 & TCOEFF={Group(+8)}) "0000 0100 000, 000, 0000 0000 1sss ss"
Right	: 1+	(EOB)

If a macroblock is "MC not coded", TYPE3="001", then the maximum lengths of consecutive 0s in [MBA+TYPE3+MVD] are as follows.

Left	: +7	(MBA=STUFF+*)
Junction:	7	(MBA=25 & TYPE3)
	6	(TYPE3 & |MVDx|>12)
Right	: 5+	(MVDy=12)

If a macroblock is "INTRA", TYPE3="0001", then the maximum lengths of consecutive 0s in [MBA+TYPE3+(INTRA Block data)] are as follows.

Left	: +7	(MBA=STUFF+*)
Junction:	8	(MBA=25 & TYPE3)
	7	(TYPE3 & DC=1)
Right	: 1+	(EOB)

If a macroblock is "INTER coded + Q", TYPE3="0000 1", then the maximum lengths of consecutive 0s in [MBA+TYPE3+QUANT2+CBP+(INTER Block data)] are as follows.

```
      Left     : +7   (MBA=STUFF+*)
      Junction:  9   (MBA=25 & TYPE3)
                 4   (TYPE3 & QUANT2=1)
                15   (Q=16 & CBP=60 & TCOEFF={Group(+8)})
                      "1 0000, 000, 0000 0000 1sss ss"
      Right    :  1+ (EOB)
```

If a macroblock is "MC coded + Q", TYPE3="0000 01", then the maximum lengths of consecutive 0s in [MBA+TYPE3+QUANT2+MVD+CBP+(INTER Block data)] are as follows.

```
      Left     : +7   (MBA=STUFF+*)
      Junction: 10   (MBA=25 & TYPE3)
                 4   (TYPE3 & QUANT2=1)
                10   (QUANT2=16 & |MVDx|>12)
                16   (MVDy=12 & CBP=60 & TCOEFF={Group(+8)})
                      "0000 0100 000, 000, 0000 0000 1sss ss"
      Right    :  1+ (EOB)
```

If a macroblock is "INTRA coded + Q", TYPE3="0000 001", then the maximum lengths of consecutive 0s in [MBA+TYPE3+QUANT2+(INTRA Block data)] are as follows.

```
      Left     : +7   (MBA=STUFF+*)
      Junction: 11   (MBA=25 & TYPE3)
                 4   (TYPE3 & QUANT2=1)
                11   (QUANT2=16 & DC=1)
      Right    :  1+ (EOB)
```

In connecting Macroblock Layer data, the maximum lengths of consecutive 0s are as follows.

```
      Left     : +7   (MBA=STUFF)
      Junction:  8   (EOB & MBA=STUFF
                      : the former MB is not "MC not coded")
                12   (MVDy=12 & MBA=STUFF
                      : the former MB is "MC not coded")
      Right    :  1+ (EOB : the last MB is not "MC not coded")
                  5+ (MVDy=12 : the last MB is "MC not coded")
```

<Group of Blocks Layer>

```
GBSC = "0000 0000 0000 0001" (+15)
GN code words with long consecutive 0s:
      "0001" (+3)                        : GN=1 (CIF/QCIF)
      "1000" (3+)                        : GN=8 (CIF)
TYPE2 code words with long consecutive 0s:
      "0000 00" (+6+)                    : TYPE2=all "0" (under study)
QUANT1 code words with long consecutive 0s:
      "0000 1" (+4)                      : Q=1
      "1000 0" (4+)                      : Q=16
[ GEI + GSPARE ] code words with long consecutive 0s:
      "0" (+1+)                          : GEI=0 (no-GSPARE)
      "1, 0000 0000 0000 0000" (16+)     : GSPARE=all "0" (under study)
```

In connecting GOB Layer data, the maximum lengths of consecutive 0s are as follows.

```
Left     : +15  (GBSC)
Junction:   3   (GBSC & GN=1)
           13   (GN=8 & TYPE2=all "0" & QUANT1=1)
           12   (QUANT1=16 & GEI=0 & MBA=STUFF)
           23   (GEI=1 & GSPARE=0 & MBA=STUFF)
                "1, 0000 0000 0000 0000, 0000 0001 111"
Right    :  1+  (EOB : the last MB is not "MC not coded")
            5+  (MVDy=12 : the last MB is "MC not coded")
```

Furthermore, in connecting GOB Layer data to form multiple GOB data, the maximum lengths of consecutive 0s are as follows.

```
Left     : +15  (GBSC)
Junction:  16   (EOB & GBSC : the former MB is not "MC not coded")
           20   (MVDy=12 & GBSC : the former MB is "MC not coded")
Right    :  1+  (EOB : the last MB is not "MC not coded")
            5+  (MVDy=12 : the last MB is "MC not coded")
```

<Picture Layer>

PSC = "0000 0000 0000 0001 0000" (+15,4+)

TR code words with long consecutive 0s:

```
"0000 0" (+5+)                    : Frame No. = 0
```

TYPE1 code words with long consecutive 0s:

```
"0000 0000 0000 0" (+13+)         : Split=off, Document=off, QCIF,
                                    others all "0" (under study)
```

[PEI1 + PARITY] code words with long consecutive 0s:

```
"0" (+1+)                         : PEI1=0 (no-PARITY)
"1, 0000 0000" (+8)               : PARITY=all "0"
```

[PEI2 + PSPARE] code words with long consecutive 0s:

```
"0" (+1+)                         : PEI2=0 (no-PSPARE)
"1, 0000 0000 0000 0000" (16+)    : PSPARE=all "0" (under study)
```

In connecting Picture Layer data, the maximum lengths of consecutive 0s are as follows.

```
39 (PSC & TR=0 & TYPE1=0 & PEI1=0 & PEI2=0 & GBSC)
23 (PSC & TR=0 & TYPE1=0 & PEI1=0 & PEI2=1)
22 (PSC & TR=0 & TYPE1=0 & PEI1=1)
21 (PSC & TR=0 & TYPE1=1)
 8 (PSC & TR=1)
34 (TR=16 & TYPE1=0 & PEI1=0 & PEI2=0 & GBSC)
18 (TR=16 & TYPE1=0 & PEI1=0 & PEI2=1)
17 (TR=16 & TYPE1=0 & PEI1=1)
16 (TR=16 & TYPE1=1)
29 (TYPE1=0x1000 & PEI1=0 & PEI2=0 & GBSC)
13 (TYPE1=0x1000 & PEI1=0 & PEI2=1)
24 (PEI1=1 & PARITY=0 & PEI2=0 & GBSC)
 8 (PEI1=1 & PARITY=0 & PEI2=1)
31 (PEI2=1 & PSPARE=0 & GBSC)
16 (EOB & PSC : the former MB is not "MC not coded")
20 (MVDy=12 & PSC : the former MB is "MC not coded")
```

Appendix 2 to Doc. #510

Example code table for CBP

CBP = 32*Y1 + 16*Y2 + 8*Y3 + 4*Y4 + 2*CB + CR

CBP	CODE	CBP	CODE
1	0101 1	33	0010 100
2	0100 1	34	0010 000
3	0011 01	35	0001 1100
4	1101	36	0011 10
5	0010 111	37	0000 1110
6	0010 011	38	0000 1100
7	0001 1111	39	0000 0001 0
8	1100	40	1000 0
9	0010 110	41	0001 1000
10	0010 010	42	0001 0100
11	0001 1110	43	0001 0000
12	1001 1	44	0111 0
13	0001 1011	45	0000 1010
14	0001 0111	46	0000 0110
15	0001 0011	47	0000 0011 0
16	1011	48	1001 0
17	0010 101	49	0001 1010
18	0010 001	50	0001 0110
19	0001 1101	51	0001 0010
20	1000 1	52	0110 1
21	0001 1001	53	0000 1001
22	0001 0101	54	0000 0101
23	0001 0001	55	0000 0010 1
24	0011 11	56	0110 0
25	0000 1111	57	0000 1000
26	0000 1101	58	0000 0100
27	0000 0001 1	59	0000 0010 0
28	0111 1	60	111
29	0000 1011	61	0101 0
30	0000 0111	62	0100 0
31	0000 0011 1	63	0011 00
32	1010		

"0000 0001 s" (+7) : CBP=27,39
"0010 000" (4+) : CBP=34
"0001 0000" (4+) : CBP=43

#499R vs. proposed CBP code table

CBP	#499R	CBP	proposed
60	000		111
4	0010		1101
8	0011		1100
16	0100		1011
32	0101		1010
12	01100		10011
48	01101		10010
20	01110		10001
40	01111		10000
28	10000		01111
44	10001		01110
52	10010		01101
56	10011		01100
1	10100		01011
61	10101		01010
2	10110		01001
62	10111		01000
24	110000		001111
36	110001		001110
3	110010		001101
63	110011		001100
5	1101000		0010111
9	1101001		0010110
17	1101010		0010101
33	1101011		0010100
6	1101100		0010011
10	1101101		0010010
18	1101110		0010001
34	1101111		0010000
7	11100000		00011111
11	11100001		00011110
19	11100010		00011101
35	11100011		00011100
13	11100100		00011011
49	11100101		00011010
21	11100110		00011001
41	11100111		00011000
14	11101000		00010111
50	11101001		00010110
22	11101010		00010101
42	11101011		00010100
15	11101100		00010011
51	11101101		00010010
23	11101110		00010001
43	11101111		00010000
25	11110000		00001111
37	11110001		00001110
26	11110010		00001101
38	11110011		00001100
29	11110100		00001011
45	11110101		00001010
53	11110110		00001001
57	11110111		00001000
30	11111000		00000111
46	11111001		00000110
54	11111010		00000101
58	11111011		00000100
31	11111100	31	000000111 *
47	11111101	47	000000110 *
27	111111100	55	000000101
39	111111101	59	000000100
55	111111110	27	000000011
59	111111111	39	000000010

* : Code word whose bit length becomes longer.

63 Patterns codeword Length

■ : coded block

		CB CR	■	■	■■
Y1 Y2 Y3 Y4	(0)	—	5	5	6
	(4)	4	7	7	8
	(8)	4	7	7	8
	(16)	4	7	7	8
	(32)	4	7	7	8
	(12)	5	8	8	8
	(48)	5	8	8	8
	(20)	5	8	8	8
	(40)	5	8	8	8
	(24)	5	8	8	9 (27)
	(36)	6	8	8	9 (39)
	(28)	6	8	8	9 * (31)
	(44)	5	8	8	9 * (47)
	(52)	5	8	8	9 (55)
	(56)	5	8	8	9 (59)
	(60)	3	5	5	6