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Irvine, California, USA 9 - 13 April 2001

Question: 4/15

SOURCE<sup>1</sup>: VOCAL Technologies Ltd. (<http://www.vocal.com>)

TITLE: G.gen: G.vdsl G.dmt.bis: G.lite.bis: Euclidean distance, gain/loss and PAR considerations of the non-square QAM constellations with independent I and Q proposed in CF-038

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### ABSTRACT

In the Clearwater meeting of Question 4 of Study Group 15, in January 2001, during the presentation and the discussion of document CF-038: "G.gen: G.vdsl G.dmt.bis: G.lite.bis: Method for Using Non-Squared QAM Constellations with Independent I&Q for Receiver Soft-Decision Decoding Techniques", some members of the committee asked for details about the power of the proposed constellations with respect to the constellations of G.992.1 and the case of rectangular constellations with independent I & Q.

This paper provides details about the Euclidean distance, gain/loss and PAR of the proposed constellations with respect to the constellations of G.992.1 and the case of rectangular constellations with independent I & Q, using as reference, the constellations of G.992.1.

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## **1. Introduction**

In the Clearwater meeting of Question 4 of Study Group 15, in January 2001, during the presentation and the discussion of document CF-038: “G.gen: G.vdsl G.dmt.bis: G.lite.bis: Method for Using Non-Squared QAM Constellations with Independent I&Q for Receiver Soft-Decision Decoding Techniques”, some members of the committee asked for details about the power of the proposed constellations with respect to the constellations of G.992.1 and the case of rectangular constellations with independent I & Q.

This paper provides details about the Euclidean distance, gain/loss and PAR of the proposed constellations with respect to the constellations of G.992.1 and the case of rectangular constellations with independent I & Q, using as reference, the constellations of G.992.1.

## **2. Euclidean distance comparison for the same average power.**

If all the constellations are normalized to the same average power, the Euclidean distance between close points of the constellations proposed in CF-038, the constellations of G.992.1 and the rectangular constellations is shown in Table 1.

**Table 1. EUCLIDEAN DISTANCE BETWEEN NEAR POINTS FOR THE SAME AVERAGE POWER**

<b>QAM Constellation</b>	<b>B</b>	<b>G.992.1 Case</b>	<b>Rectangular Case</b>	<b>Independent I&amp;Q CF-038 Case</b>
8	3	1	1	1.0802
32	5	1	0.899719	0.916731
128	7	1	0.900702	0.986828
512	9	1	0.901456	0.987754
2048	11	1	0.901406	0.988227
8192	13	1	0.901465	0.988459
32768	15	1	0.901481	0.988083

## **3. Gain/Loss comparison for the same average power.**

The Gain/Loss of the constellations proposed in CF-038, the constellations of G.992.1 and the rectangular constellations is shown in Table 2.

For the case of 8 QAM, the technique presented in CF-038 has a gain of 0.67 dB with respect to the current G.992.1. For 32 QAM, the technique presented in CF-038 has a loss of 0.75 dB with respect to the current G.992.1. For the rest of the constellations, the technique presented in CF-038 has a loss of 0.11 dB with respect to the current G.992.1. In average, the technique presented in CF-038 has a loss of 0.087 dB with respect to the current G.992.1

**Table 2. GAIN/LOSS FOR THE SAME AVERAGE POWER**

<b>QAM Constellation</b>	<b>b</b>	<b>G.992.1 Case</b>	<b>Rectangular Case</b>	<b>Independent I&amp;Q CF-038 Case</b>
8	3	0	0	0.670082
32	5	0	-0.91787	-0.75516
128	7	0	-0.90838	-0.11517
512	9	0	-0.90111	-0.10702
2048	11	0	-0.90159	-0.10286
8192	13	0	-0.90102	-0.10083
32768	15	0	-0.90087	-0.10413

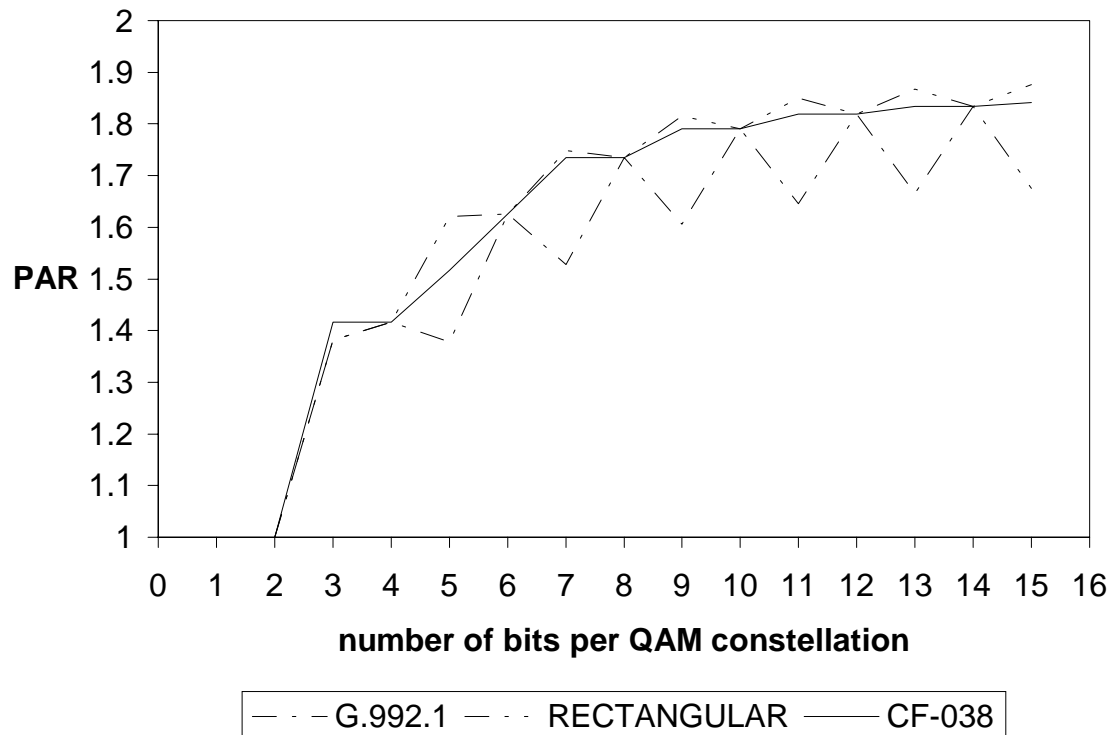
#### **4. PAR.**

The PAR of the constellations proposed in CF-038, the constellations of G.992.1 and the rectangular constellations is shown in Table 3.

**Table 2. PAR**

<b>QAM Constellation</b>	<b>b</b>	<b>G.992.1 Case</b>	<b>Rectangular Case</b>	<b>Independent I&amp;Q CF-038 Case</b>
8	3	1.381966	1.381966	1.416408
32	5	1.378421	1.620454	1.517217
128	7	1.528274	1.74836	1.735191
512	9	1.605773	1.815297	1.791079
2048	11	1.645341	1.849647	1.819464
8192	13	1.665353	1.867147	1.833776
32768	15	1.675481	1.87598	1.840989

Figure 1 provides a graphical representation of the PAR for the three types of constellations. It is clear that the constellation proposed in CF-038 provide a smoother PAR variation for all range of constellations.



## **5. Summary**

This paper presents details on Euclidean distance between close points of the constellations proposed in CF-038, the gain/loss of the different constellations proposed in CF-038 and the rectangular constellations with reference to the current constellations of G.992.1 and the PAR of the constellations of G.992.1, the rectangular constellations and the constellations proposed in CF-038.

1. Agenda Item: G.992.1.bis issue 4.6 and G.992.2.bis issue 10.14. G.vdsl issue 11.17
2. Expectations: The committee accepts the technique described in this paper.