IEEE P802.11
Wireless LANs

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| 4096 QAM definition |
| Date: 2020-01-10 |
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Abstract

This submission provides a definition of 4096 QAM.

# Introduction

4096 QAM constellation support has been discussed for 11be.

In 4096 QAM, each constellation point encodes 12 bits. The first 6 bits determine the $I$ value of the constellation point, while the subsequent 6 bits determine the $Q$ value of the constellation point.

The final constellation point is given by:

$$d=\left(I+jQ\right)×K\_{MOD}$$

To fully define 4096 QAM, we need to specify the mapping of bits to the $\left(I,Q\right)$ grid and the value of the normalization constant $K\_{MOD}$. Both are specified below.

# Constellation coding of 4096 QAM

Each constellation point is characterized by an $I$ and $Q$ coordinate on an odd-integer grid between -63 and 63. Each of these coordinates corresponds to a 6-bit sequence as shown in Table 1. The $I$ corresponds to the first set of 6 bits and the $Q$ to the second set of 6 bits. Both $I$ and $Q$ follow the encoding shown in Table 1.

Like previously defined constellations, this proposed encoding follows Gray-coding to minimize the number of bit errors per symbol error.

Table 1: Mapping of constellation coordinates to bits

|  |  |
| --- | --- |
| **Coordinate** | **Bits** |
| -63 | 0 | 0 | 0 | 0 | 0 | 0 |
| -61 | 0 | 0 | 0 | 0 | 0 | 1 |
| -59 | 0 | 0 | 0 | 0 | 1 | 1 |
| -57 | 0 | 0 | 0 | 0 | 1 | 0 |
| -55 | 0 | 0 | 0 | 1 | 1 | 0 |
| -53 | 0 | 0 | 0 | 1 | 1 | 1 |
| -51 | 0 | 0 | 0 | 1 | 0 | 1 |
| -49 | 0 | 0 | 0 | 1 | 0 | 0 |
| -47 | 0 | 0 | 1 | 1 | 0 | 0 |
| -45 | 0 | 0 | 1 | 1 | 0 | 1 |
| -43 | 0 | 0 | 1 | 1 | 1 | 1 |
| -41 | 0 | 0 | 1 | 1 | 1 | 0 |
| -39 | 0 | 0 | 1 | 0 | 1 | 0 |
| -37 | 0 | 0 | 1 | 0 | 1 | 1 |
| -35 | 0 | 0 | 1 | 0 | 0 | 1 |
| -33 | 0 | 0 | 1 | 0 | 0 | 0 |
| -31 | 0 | 1 | 1 | 0 | 0 | 0 |
| -29 | 0 | 1 | 1 | 0 | 0 | 1 |
| -27 | 0 | 1 | 1 | 0 | 1 | 1 |
| -25 | 0 | 1 | 1 | 0 | 1 | 0 |
| -23 | 0 | 1 | 1 | 1 | 1 | 0 |
| -21 | 0 | 1 | 1 | 1 | 1 | 1 |
| -19 | 0 | 1 | 1 | 1 | 0 | 1 |
| -17 | 0 | 1 | 1 | 1 | 0 | 0 |
| -15 | 0 | 1 | 0 | 1 | 0 | 0 |
| -13 | 0 | 1 | 0 | 1 | 0 | 1 |
| -11 | 0 | 1 | 0 | 1 | 1 | 1 |
| -9 | 0 | 1 | 0 | 1 | 1 | 0 |
| -7 | 0 | 1 | 0 | 0 | 1 | 0 |
| -5 | 0 | 1 | 0 | 0 | 1 | 1 |
| -3 | 0 | 1 | 0 | 0 | 0 | 1 |
| -1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 3 | 1 | 1 | 0 | 0 | 0 | 1 |
| 5 | 1 | 1 | 0 | 0 | 1 | 1 |
| 7 | 1 | 1 | 0 | 0 | 1 | 0 |
| 9 | 1 | 1 | 0 | 1 | 1 | 0 |
| 11 | 1 | 1 | 0 | 1 | 1 | 1 |
| 13 | 1 | 1 | 0 | 1 | 0 | 1 |
| 15 | 1 | 1 | 0 | 1 | 0 | 0 |
| 17 | 1 | 1 | 1 | 1 | 0 | 0 |
| 19 | 1 | 1 | 1 | 1 | 0 | 1 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 |
| 23 | 1 | 1 | 1 | 1 | 1 | 0 |
| 25 | 1 | 1 | 1 | 0 | 1 | 0 |
| 27 | 1 | 1 | 1 | 0 | 1 | 1 |
| 29 | 1 | 1 | 1 | 0 | 0 | 1 |
| 31 | 1 | 1 | 1 | 0 | 0 | 0 |
| 33 | 1 | 0 | 1 | 0 | 0 | 0 |
| 35 | 1 | 0 | 1 | 0 | 0 | 1 |
| 37 | 1 | 0 | 1 | 0 | 1 | 1 |
| 39 | 1 | 0 | 1 | 0 | 1 | 0 |
| 41 | 1 | 0 | 1 | 1 | 1 | 0 |
| 43 | 1 | 0 | 1 | 1 | 1 | 1 |
| 45 | 1 | 0 | 1 | 1 | 0 | 1 |
| 47 | 1 | 0 | 1 | 1 | 0 | 0 |
| 49 | 1 | 0 | 0 | 1 | 0 | 0 |
| 51 | 1 | 0 | 0 | 1 | 0 | 1 |
| 53 | 1 | 0 | 0 | 1 | 1 | 1 |
| 55 | 1 | 0 | 0 | 1 | 1 | 0 |
| 57 | 1 | 0 | 0 | 0 | 1 | 0 |
| 59 | 1 | 0 | 0 | 0 | 1 | 1 |
| 61 | 1 | 0 | 0 | 0 | 0 | 1 |
| 63 | 1 | 0 | 0 | 0 | 0 | 0 |

# Normalization

To normalize the constellation to unit energy, the constellation points need to be scaled with a factor 1/sqrt(2730).

In other words: $K\_{MOD}=\frac{1}{\sqrt{2730}}$.

## Graphical illustration

The 802.11 standard and its various amendments typically include a graphical illustration of the constellation. Some examples are shown below in Figure 1 and Figure 2. The density of the constellation may make it hard to use the graphical representation as was done BPSK and QAM4-QAM1024.



Figure 1: 4096 QAM constellation

The upper right quadrant of Figure 1 is shown in Figure 2.



Figure 2: Upper right quadrant of 4096 QAM

# Summary

This submission presents the definition of 4096 as a mapping of 12 bits to a point on an odd-integer complex-valued grid, followed by normalization.