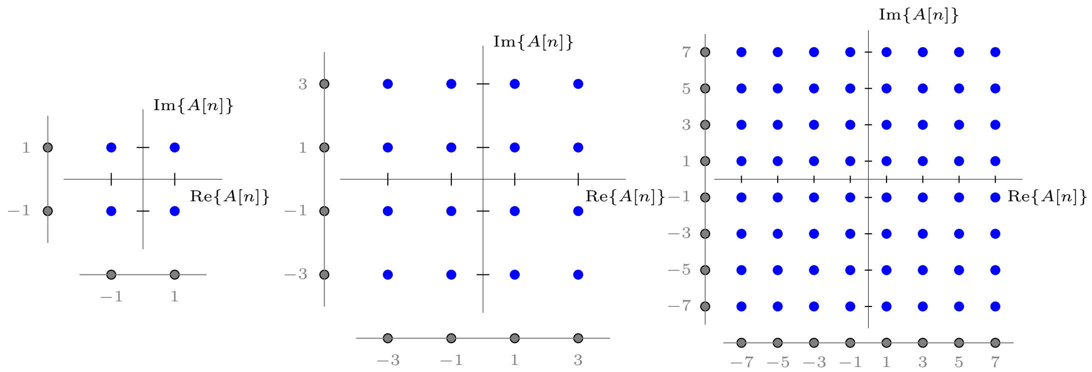
## 3.b. Constellations for BP PAM

Recalling that $A[n] \in \{\mathbf{a}_1, \dots, \mathbf{a}_M\} = \mathcal{A} \in \mathbb{C}$ with $|\mathcal{A}| = M$, we have two ways to design the complex constellation:

- **QAM**: The quadrature amplitude modulation (QAM) constellation is defined as $A[n] = A_I[n] + \mathrm{j}A_Q[n]$, where both $A_I[n]$ and $A_Q[n]$ take values independently and each one is a $\sqrt{M}$-PAM constellation, i.e. $A_I[n] \in \{\pm1, \pm3, \dots, \pm(\sqrt{M}-1)\}$ and $A_Q[n] \in \{\pm1, \pm3, \dots, \pm(\sqrt{M}-1)\}$. Note that in this case $M = 2^m$ where $m \geq 2$(bits/symbol) is an even number, i.e. $m = \{2, 4, \dots\}$
  - ▷ $\mathcal{E}_s = \frac{2(M-1)}{3}$ if the symbols are equi-probable.
  - ▷ The Gray encoding is done independently in each dimension.




4-QAM (2-PAM)×(2-PAM) | 16-QAM (4-PAM)×(4-PAM) | 64-QAM (8-PAM)×(8-PAM)

- **PSK**: The phase shift keying (PSK) constellation $A[n] = A_I[n] + \mathrm{j}A_Q[n] = \sqrt{\mathcal{E}}e^{\mathrm{j}\varphi[n]}$, Note that in this case both $A_I[n] = \sqrt{\mathcal{E}_s}\cos(\varphi[n])$ and $A_Q[n] = \sqrt{\mathcal{E}_s}\sin(\varphi[n])$ and therefore do not take values independently. $\varphi[n] = \{0, \frac{2\pi}{M}, \dots, \frac{2\pi(M-1)}{M}\}$ whose phase values are taken independently.
  - ▷ Is a constant amplitude constellation with energy $\mathcal{E}_s$ for equiprobable symbols.
  - ▷ We use Gray encoding.