# IEEE P802.15
# Wireless Personal Area Networks

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| Project | IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs) | |
| Title | Proposed Text on π/2 BPSK and (G) MSK description | |
| Date Submitted | September, 9th, 2008 | |
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| Re: | 802.15.3c Teleconference Meeting | |
| Abstract | IEEE 802.15 Task Group TG3c Comment Resolution | |
| Purpose | Resolutions for the π/2 BPSK and (G) MSK description | |
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#### 12.2.2.1.1 π/2 BPSK, Pre-coded (G)MSK

The π/2-shift BPSK (π/2 BPSK) modulation uses two phases separated by π radian, as illustrated in Figure 189(a). The π/2 phase shift is made counter-clockwise to eliminate the π phase shift. Figure 189(a) shows signal constellation of π/2 BPSK signals. As shown in Figure 189(a), the black dot indicates the initial constellation point on the horizontal axis. In the next bit timing, the black dot is rotated to either hollow dot on the vertical axis. If $b_0$, $b_1$, ..., $b_{n-1}$ are unipolar bits to be transmitted, they are mapped to bipolar bits $d_0$, $d_1$, ..., $d_{n-1}$, where bit “0” is mapped on “-1” and bit “1” on “+1”. The bipolar bit stream is then mapped onto constellation points $z_n$ as

$$z_n = j^n \cdot d_n \qquad n = 0,1,..., N \ ,$$

where $j$ denotes π/2 phase rotation. This means the phase difference between two consecutive bits is always π/2. Note that the normalization factor is 1 for π/2 BPSK and $z_0$ is defined in 12.2.3.

Pre-coded MSK are continuous phase modulation schemes by applying differential pre-coding before the MSK modulation. Note that the MSK constellation mapping is approximately equivalent to the π/2-BPSK constellation as shown in Figure 189(b). The differential pre-coding is defined by

$$a_n = d_n \cdot d_{n-1}, \quad n = 0,1,..., N-1,$$

where $d_{-1}$ =1. The differential pre-coded bits are then fed to MSK modulator. The differential pre-coded bits $a_n$ and the previous constellation point $z_{n-1}$, are encoded to the constellation points $z_n$ for the MSK as shown below.

$$z_n = z_{n-1} \cdot (j \cdot a_n), \quad n = 0,1,..., N,$$

where, $z_{-1}$ is $-j$. This encoding means the odd bits are mapped onto the real axis and the even bits are mapped onto the imaginary axis, as shown in Figure 189(b). Hence it is equivalent to the π/2-BPSK constellation as shown in Figure 189(a) (Note that the normalization factor is 1). The maximum phase shift of MSK is equal to π/2 radian. The maximum phase shift of GMSK is equal to or less than π/2 radian due to Gaussian filtering. Note that filtered waveform of each modulation shall satisfy Transmit PSD mask as in 12.2.7.4.

(For more detailed information on the equivalence of p/2 BPSK and pre-coded (G)MSK , please refer http://kom.aau.dk/project/sipcom/SIPCom05/sites/sipcom8/courses/SIPCom8-2/notes.pdf page160).

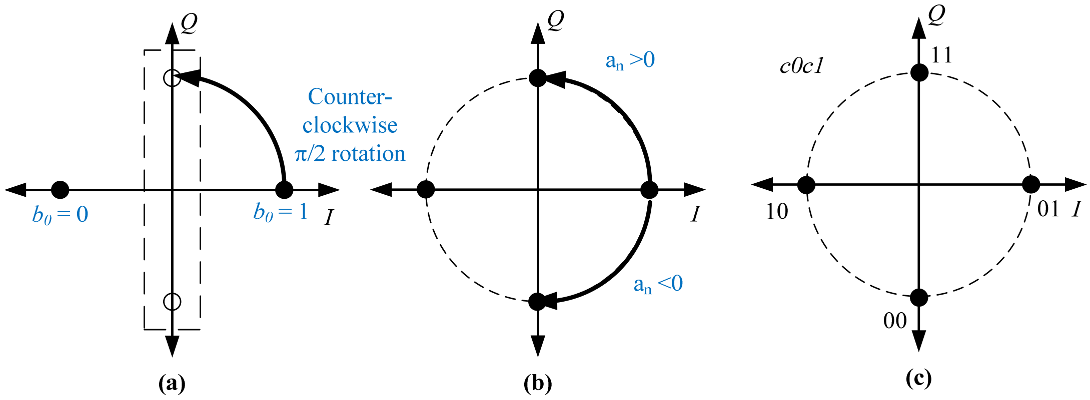


**Figure 189—Constellation maps for modulation schemes: (a) π/2 BPSK, (b) pre-coded (G)MSK, (c) π/2 QPSK**