# Physical Layer Design for a Narrow Band Communication System

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***Abstract*—This a simple document explaining a question about the concept of similar triangles.**

Download all python codes from

```
svn co https://github.com/SiddharthPh/
    Summer2020/trunk/geometry/codes
```

and latex-tikz codes from

```
svn co https://github.com/gadepall/school/trunk/
    ncert/geometry/figs
```

## 1 Specifications

1.0.1. QPSK

$$\mathbf{y} = \mathbf{s} + \mathbf{n} \tag{1.0.1.1}$$

where $\mathbf{s} \in \{s_0, s_1, s_2, s_3\}$

$$s_0 = \begin{pmatrix} \sqrt{E_s} \\ 0 \end{pmatrix} \tag{1.0.1.2}$$

$$s_1 = \begin{pmatrix} 0 \\ \sqrt{E_s} \end{pmatrix} \tag{1.0.1.3}$$

$$s_2 = \begin{pmatrix} -\sqrt{E_s} \\ 0 \end{pmatrix} \tag{1.0.1.4}$$

$$s_3 = \begin{pmatrix} 0 \\ -\sqrt{E_s} \end{pmatrix} \tag{1.0.1.5}$$

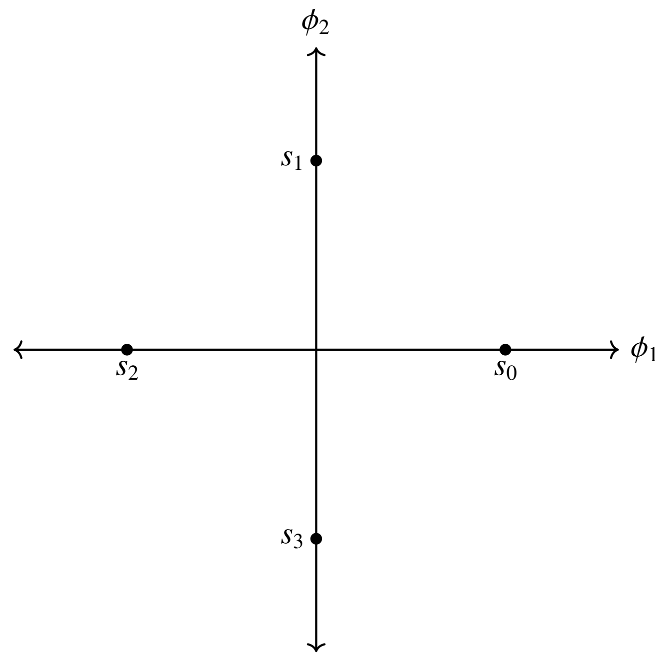


Fig. 1.0.1.1: constellation diagram

1.0.2. Encoding
$s_0$ denote bits 00, $s_1$ denote bits 01, $s_2$ denote bits 11,$s_3$ denote bits 10.

1.0.3. Decoding
Let $\mathbf{r}$ be the received bits, $\mathbf{r} = [r_1,r_2]$.

$$r_1 = \begin{cases} 0, & \mathbf{y} \in D1 \cup D2 \iff y_1 + y_2 > 0 \\ 1, & \mathbf{y} \in D3 \cup D4 \iff y_1 + y_2 < 0 \end{cases} \tag{1.0.3.1}$$

$$r_2 = \begin{cases} 0, & \mathbf{y} \in D1 \cup D4 \iff y_2 - y_1 < 0 \\ 1, & \mathbf{y} \in D2 \cup D3 \iff y_2 - y_1 > 0 \end{cases} \tag{1.0.3.2}$$

From eq.1.0.3.1 and eq.1.0.3.2
For detecting $s_0$, $y_1 > -y_2$ and $y_1 > y_2$.
For detecting $s_1$, $y_1 > -y_2$ and $y_1 < y_2$.
For detecting $s_2$, $y_1 < -y_2$ and $y_1 < y_2$.
For detecting $s_3$, $y_1 < -y_2$ and $y_1 > y_2$.

1.0.4. The following code has simulation of QPSk.

```
codes/qpsk.py
```

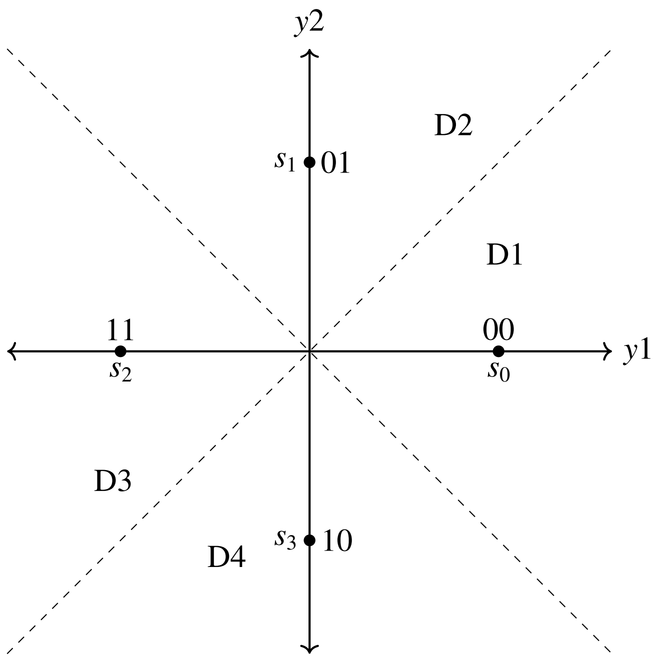


Fig. 1.0.3.1: decision regions