

SIGNAL PROCESSING & SIMULATION NEWSLETTER

TUTORIAL 2 - DIFFERENTIAL ENCODING

One of the common difficulties in communications engineering is that often the same terms are used to represent different ideas. Differential Encoding is one such term. We will describe here two common ways this term is used and unless you know these differences, they can lead to confusion.

Differential Encoding – Is used to provide polarity reversal protection

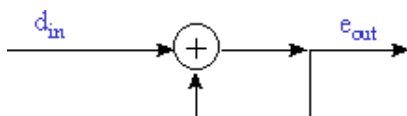
Bit streams going through the many communications circuits in the channel can be un-intentionally inverted. Most signal processing circuits can not tell if the whole stream is inverted. This is also called phase ambiguity. Differential Encoding is used to protect against this possibility. It is one of the simplest form of error protection coding done on a baseband sequence prior to modulation.

A Differential Coding system consists of a modulo 2 adder operation as shown below.

d_{in} = Data sequence in

e_{out} = Differentially Encoded data sequence out

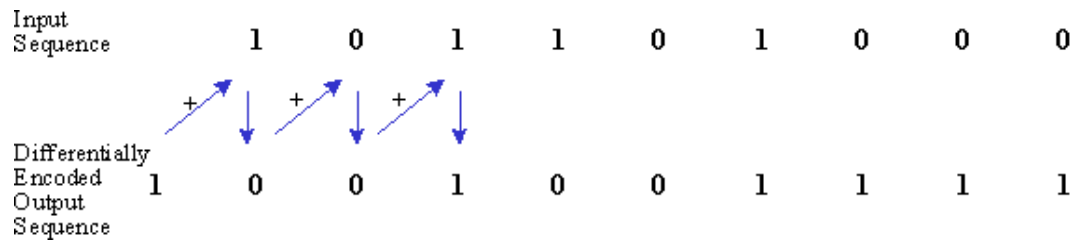
Encoding



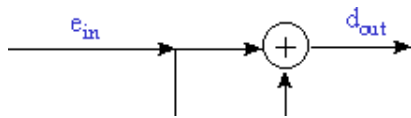
$$E_{out} = d_{in} + e_{n-1}$$

Here is how it works. Let's take a sequence as shown below. The Encoding circuit above has a reference bit (it can be 0 or 1, it doesn't matter). The incoming data sequence is added to this reference bit and forms the second bit of the encoded sequence. This bit is then added to the next data bit to

continue the process as shown below.



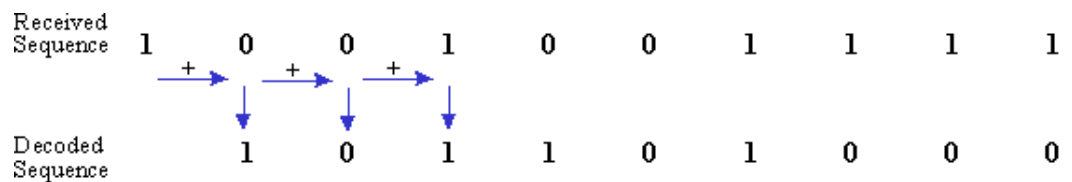
Decoding



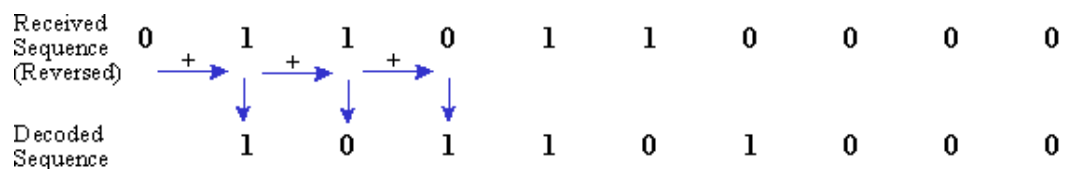
The decoding process reverses the above. The incoming bits are added together to recreate the input data sequence.

There are now two possibilities, 1. that the received sequence was not reversed and 2. that it was. let's see how the circuit deals with each of these two possibilities.

Bit Sequence Received Correctly



Bit Sequence Received Reversed



In either case, by the magic of binary numbers, we were able to get the original bit sequence back.

Differential Encoding - Used to provide phase reference

Differential Encoding as in DEBPSK or DPSK) is another way to apply this same concept. Although the concept is exactly the same, here the purpose of Differential Encoding is to encode the information in terms of phase changes. DPSK or DEBPSK is used in situations where coherent detection is not possible and the signal phase transitions are used to decode the data. We will look at the details of this modulation in a later release.

Summary:

Main purpose of Differential Encoding is to protect against polarity reversals of input bit sequences. Hence Differentially Encoded data sequences have a slightly superior error performance. Differential Encoding is also used to provide a way to decode a BPSK signal, called DEBPSK or DPSK. The operation is exactly the same as described above.

In software simulation, there is no chance that a bit sequence will be reversed. So when creating a simulation model of a Differentially Encoded sequence, we can ignore this baseband coding. However, when modeling a DPSK system, we need to consider its implication since it is essential to the system.