INTRODUCTION TO

"REDUCED ENERGY ENCODING TECHNOLOGY"

INTELLECTUAL PROPERTY

of

Rice Electronics

NOTE: This is an introductory document.

Contact Rice Electronics directly for further information.

Filename: Energy Reduce Rev L

OVERVIEW

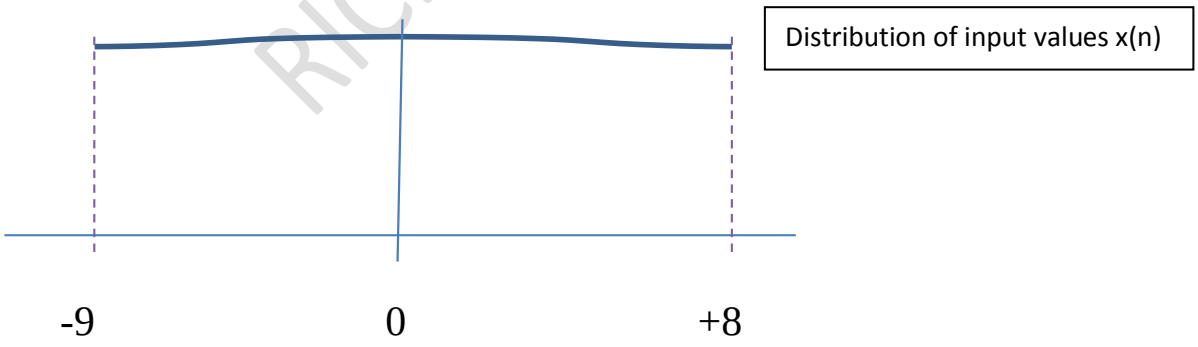
The Reduced Energy Encoding IP reduces the energy/power levels of digital signals, without loss of information content. The technology converts random data sequences into vectors of non-uniform value distribution(s) and overall lower energy.

The proprietary processes are of utility in communications. An example is OFDM (Orthogonal Frequency Domain Multiplexing) wireless communications. In this application the IP can be employed in the generation of low-power waveforms. This is further discussed in this document and elsewhere at this site.

The IP encoding structures accept random data sequences and produce output sequences of non-uniform (e.g., Gaussian) data distribution. The output (encoded) sequences are of significantly less power than the input sequence.

The IP decoding structures can effect lossless recovery of the random data input sequence. Figures 1and 2 below provide an example of data probability distributions for the input/output sequences.

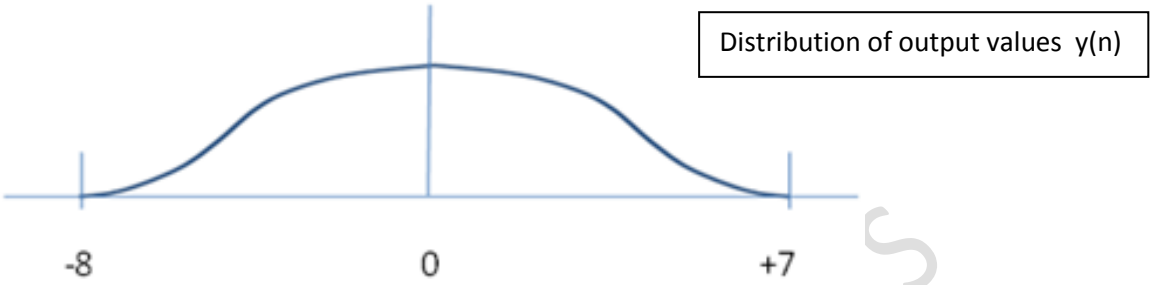
Figure 1 depicts the distribution of values of some N-point Input Sequence, x(n). The Input Sequence data consists of 18-state integer values uniformly distributed from (-9) to (+8).



Input Sequence Probability Distribution

Figure 1

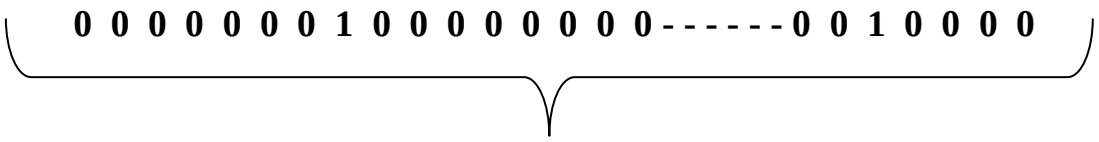
The IP encoder converts the above sequence into an Output Sequence and "Secondary Artifact(s)". The Output Sequence consists of an N-point vector y(n) comprised of 16-state integer values. These values have a non-uniform (e.g., Gaussian) distribution from (-8) to (+7). The distribution is depicted in Figure 2 below.



Output Sequence Probability Distribution

Figure 2

The IP may also produce additional low-power "Secondary Output Artifacts". One of these is a small number (e.g. N/8) of random bits. The other is a "pulse train" of low-duty cycle. A typical range of the duty cycle may be from 4% to 8%. This Artifact is typically of N/2 points in length, and is exemplified in Figure 3 below.



N/2 Points

Secondary Output Artifact

Figure 3

In the above example, the bulk of the encoded data exists in the "Output Sequence" y(n). The energy of this artifact may be typically 50% less than that of the original Input Sequence x(n) as measured by;

$\sum y^2(n) / \sum x^2(n)$

where summation is over all N values for each sequence.

In OFDM systems such as 5G radio, the values of the Output Sequence y(n) can be mapped to QAM constellations for low-power modulation of subcarriers. This produces OFDM "symbols" of substantially lower power than that achieved with conventional methods.

A "Secondary Artifact" is the pulse train, and is inherently "low-power" in relation to the Output Sequence. This Artifact can be processed in various ways to support low-power communications. For example, it may be subjected to further encoding techniques for purposes of compression. As an alternative to encoding, waveform techniques could be used to represent the Pulse Train in low power form, as might be achieved with spread spectrum techniques.

The Output Sequence itself is based primarily on encoding techniques, and can therefore be uses in conjunction with common OFDM waveform compression techniques such as peak-clipping.

Rice Electronics is pursuing application of the Reduced Energy IP to waveform generation. Derivative advantages are reduced average power and Peak-to-Average Power (PAPR) levels in OFDM systems. Such systems range from 5G wireless networks to various broadcast systems.

The proprietary methods include mapping the Encoded Data (Output Sequence and Pulse Train Artifact) to QAM constellations for modulation of orthogonal sub-carriers within OFDM symbols. The Reduced Energy Encoding Technology therefore encompasses methods and structures related to;

- Encoding random data into the low-energy formats referenced above
- Mapping these formats into orthogonal set(s) of frequency components of reduced power levels
- Structure and processes for performing the above functions in real time

The IP offers substantial advantages for advanced communication systems. In particular, it facilitates operation at lower power levels with minimal dilution of channel capacity. The utility extends to many areas, including;

- Prolonged battery life in mobile devices
- Reduction of mutual interference in wireless, multi-user access systems
- Improved noise immunity in variety of systems

At this time, certain discussions of the Reduced Energy Encoding IP may be excluded from this document. These may include;

- Specifics regarding proprietary encoding/decoding processes
- Details relative to QAM mapping and waveform modulation
- Real-time implementation considerations
- Demonstration vehicle configuration(s) and status

SUMMARY

The Reduced Energy Encoding IP of Rice Electronics has broad implications for communications. It is a novel Technology for managing issues of power control in wireless systems. Components of the Technology include encoding, waveform generation and real-time processing methods and structures.

CONTACT COMPANY DIRECTLY FOR FURTHER INFORMATION

NOTES: This document contains preliminary information. Some Intellectual Properties referenced in this document may have patents pending.

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