An Approch For Nanoscale Wireless Communication Using Minimum Energy Channel Code

Prof.Anuradha Deshpande[4], Mahesh Adhav[1], Shekhar Zende[2], Prashant Khati[3]

Abstract

In this new age of wireless nanoscale communications the energy requirement plays an important role. It is necessary to minimize the energy requirement for nanoscale wireless communication.In this paper a new coding technique and modulation scheme is used along with it to achieve minimum energy channel codes.The existing coding techniques are not suitable to minimize the energy. In this paper we anylatically show that minimum energy channel codewords are encoded and decoded perfectly.The analytical result of energy requirement to correct decoded result are shown in graph.The minimum energy channel codes are very popular codes than the existing code such as Golay codes, RS codes,Block codes etc. Our coding technique outperforms the existing techniques in the evaluation of energy

*Keywords**-OOK modulation, nanoscale wireless communication, minimum energy coding, THz channel***

I. INTRODUCTION

The advancement in the semiconductor industries has allowed the development of small, less expensive, devices with low power consumption known as sensor nodes. These sensors are endowed with sensing and processing data and communication components that convert them in multi-functional, flexible platforms. A wireless sensor network (WSN) is consists of many of these tiny sensor nodes that come together to complete a common task and are densely deployed in the area to bemonitored. A broad variety of applications ranging from geophysical monitoring (seismic activity) to precision agriculture (soil management), habitat and environmental monitoring, military systems and business processes (supply chain management) are supposed to be implemented on WSN.

Most existing network protocols and algorithms for traditional wireless networks cannot effectively address the power constraint and other constraints of sensor networks. To realize the vision of sensor networks, it is imperative to develop various energy-efficient coding technique in order to efficiently use the limited power in each sensor node and prolong the lifetime of the network. A suitable tuning of the nodes' transmission powerhelps to reduce the overall network consumption by transmitting at lower power levels when possible.

Carbon nanotubes (CNT) is the most important block of the nanosensors. CNT work in the THz band. This band is not used by any macro applications therefore it is available for the nano communication.

The problem with the THz band is the absorption of electromagnetic waves by water moleculas which causes noise and path loss.It is a difficult task to employ channel codes at the nanoscale. The coding technique for nanoscale channel consider the power consumption because the nanonodes run on a strict energy budget. As stated earlier the conventional channel codes can not fulfill the needs of nanosensor to overcome this problem we dwvelope a minimum energy channel code(MEC)that is suitable for nanocommunication along with OOK modulation. In this technique the average codeword weight of the channel codes is reduced and using OOK modulation average energy is reduced as the weight reduces .

II. PROBLEM STATEMENT

Aim of this paper is to develop the new coding technique which will reduce the energy requirement of the nanoscale communication system. By Literature review we found the importance of efficient energy transmission in nano sensor communication. We focus on reducing the average codeword weight of the codewords and develope the minimum energy codes along with OOK modulation.

III. LITERATURE REVIEW

In different applications wireless nanosensor networks can be used for data collection and sensing with low power

ISSN: 2278 – 1323

consumption and very high resolution [1].CNT sensor networks and the major challenges which are present in their realisation are introduced by the authors in [3].The survey on state_of_the_art in nanosensors and applications and design challenges are given in [1]. The study on noise characteristics, capacity and channel absorption in THz band is done in [4]. Despite their research, channel coding used in nanoscale wireless communications is a barren field. To eliminate interferences in nanonetworks the low weight codes with femtosecond-long OOK pulses is recently proposed in [8]. However, the need of developing channel codes to achieve reliable, energy efficient nano communication system has not been addressed.

In [5], to reduce the energy requirement for sensor networks the idea of using channel codes having low weight with OOK modulation is proposed first. We can define minimum energy channel coding as choosing codewords for each output of source so that the mean codeword energy is less than any other choice of codewords mapping.It is shown that, for achieving minimum average code weight in the given codebook the codewords are sorted in increasing code weight order and source symbols are assigned in decreasing order of probability. This means the codeword having lowest code has most probable source symbol. Later,using codewords with maximum weight of 1 is proposed by [9].

Such a mapping corresponds to minimum energy coding, if the all-zero codeword is mapped to the most probable source outcome. However, this code is not reliable since its code distance is 1, and any bit error pattern is uncorrectable. Therefore, development of reliable minimum energy codes has been an open issue.

In our paper, we present a new modulation technique particularly suitable for nanoscale communications in THz band. In contrary to the existing technique in which whole THz band is used, our technique eliminates the need to deal with performance degradation due to several molecular noises and absorption. Later we discuss the need of reducing the energy consumption.

IV. MULTICARRIER OOK MODULATION

In multicarrier OOK modulation the multiple carrier frequency are used for transmitting the codeword. The nanoscale wireless communication characterized with thz frequency that purpose we use. Each codeword is transmitted parallel over different carrier frequency, the carrier frequency can be choose in thz band.in thz band multiple frequency windows which have low noise and less absorption are available. It depends on transmission path ,distance and water vapors amount[4] .the carrier frequency can be choose in thz windows. In nanoscale communication CNT are used. The CNT are used for radiating the carrier frequency.each carrier frequency windows utilize separately for different codeword, to utilize the different frequency the bandwidth is increased and the information is secured from noise. Decreasing the bandwidth gives the results with increased energy per consumption symbol, means symbol duration increases. For this purpose we choose the same bandwidth as available in frequency window. Therefore long sinusoidal pulses of duration in picoseconds are used which having frequency band of 100-200 Ghz, which corresponds to the width of the most windows in thz channel [4.]

Channel codes having minimum average weight are used with OOK modulation in each carrier to optimize energy requirement. Proposed scheme gives minimum hamming distance and minimum energy. The delays due to lengthy codewords are eliminated due to multicarrier modulation in wireless nanosensor networks.

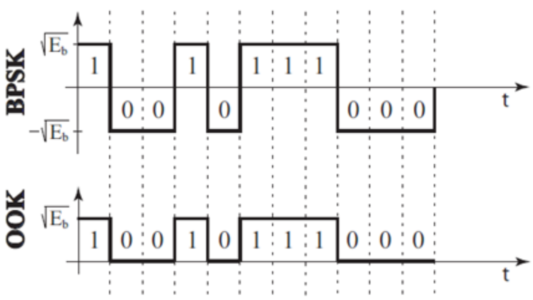

Fig 1. BPSK and OOK modulation scheme

As shown in fig 1, in OOK modulation the pulse is high only when symbols 1 is transmitted. Therefore decreasing the average code weight means reducing no. of 1’s in codeword can efficienty reduce the energy requirement.

ISSN: 2278 – 1323

V. WIRELESS NANOSENSORS

Creating a compact, reliable source of terahertz (THz) radiationis one of the most challenging task. Despite the fact that technology in THz range is at the edge of photonic and microwavetechnologies, it is quiteless developed as compared to the achievements in the other two technologies. There are very few available devices for the THz frequency region, and most of them lack the precision required to perform accurate measurements. One of the latest trends in THz technology is to use single-walled carbon nanotubes (SWNTs) as important blocks of high-frequency devices.

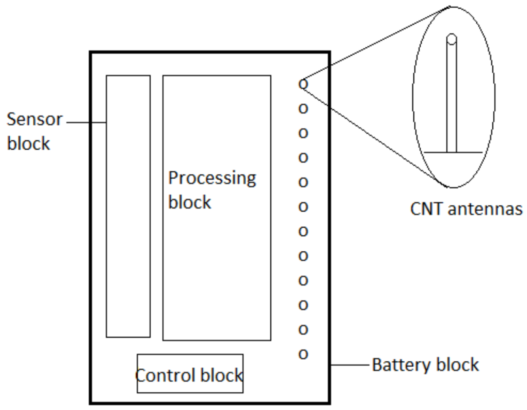

Fig 2. Proposed architecture of nanosensor node

As shown in fig 1, we are considering a cell based wireless nanosensor netwok. This cell is having a micronode and nanonodes connected around it. Micronode handles all the control and scheduling activities within the cell. This reduces the complexity of nanonodes. Micronode sends an activation signal to the nanonodes and then and only then nanonodes start transmission.

The activation signal in KHz band is used. The task of micronode is to synchronize the nanosensors. Micronodes operate in THz band. studies have shown that that the CNT bundles can be used for THz reception.

VI. MINIMUM ENERGY CHANNEL CODING

We propose a new channel coding technique which focuses on minimizing the average code weight that means it result into reducing the average codeword energy for the systems which use OOK modulation. In OOK modulation no energy is dissipated when symbol 0 is transmitted and energy is required only when symbol 1 is transmitted.

In case of block codes codebook is any set of codewords, mapped to the source symbol. Weight is nothing but the number of non-zero entries in the codewords that is number of 1's in the codewords also the Hamming distance between two codewords can be defined as the number of bits by which they differ from each other. The codes having distance *d* can correct the number of errors which is given by $\left\lceil \frac{d-1}{2} \right\rceil$. When the error correction is more the reliability of system increases.

Low weight codewords mean less number of 1's that is these codewords require less energy. We can use OOK modulation for this purpose because in OOK modulation the symbol 0's require absolutely no energy. In our proposed minimum energy coding technique we develop the channel codes with code distance *d* which reduces codeword weight that we expect and guarantee reliability.

Let M, d, $pmax$, X represent number of codewords, codedistance, maximum probability in any discrete distribution and the source random variable, respectively.

Lemma 1. For any finite M, there exists a finite n_0 such that a constant weight code C of length-n_0 containing the codeword c can be constructed with code distance d, if and only if weight(c) $\geq \left\lceil \frac{d}{2} \right\rceil$:

$\exists C : dist(C) \geq d$ for $c \in C \Leftrightarrow weight(c) \geq \lceil d/2 \rceil$.

Lemma 2. Any codebook with code distance of d contains at most a single codeword with weight less than$\lceil d/2 \rceil$.

Lemma 3. Any two codeword$C_i$andC_j of a code with distance d should satisfy the inequality

$weight(C_i) + weight(C_j) \geq d.$

Let C_i be the code with weight enumerator

$$WC_i(z) = z^{(d/2)-i} + (M+1)\, z^{(d/2)+i} \qquad (1)$$

The code C_i contains a single codeword with weight $\lceil d/2 \rceil - i$ and other codewords have weight $\lceil d/2 \rceil + i$. Let codewordhaving weight $\lceil d/2 \rceil - i$be assigned to the source symbol withmaximum

ISSN: 2278 – 1323

probability, i.e., p_{max}. Let EC_i represent code weight that is expected for code C_i.

Lemma 4.

$EC_{i+k} < EC_i$ if $p_{max} > 0.5$, $\forall k > 0$.

Proof: Let β represent $\lceil d/2 \rceil$. Then

$$EC_i = p_{max}(\beta - i) + (1 - p_{max})(d - \beta + i)$$
$$= p_{max}(2\beta - 2i - d) + d - \beta + i.$$

$\Rightarrow EC_i - EC_{i+k} = k(2p_{max} - 1)$.

Hence, since k is positive, $EC_{i+k} < EC_i$ if $p_{max} > 0.5$.

VII. MEC PARAMETERS

Power consumed for codeword i is $P_i = w_i P_{sym}$, where P_{sym} is the symbol power. Then we can calculate average power as

$$E(P) = \sum_{i=1}^{M} w_i p_i P_{sym} = E(w) P_{sym}. \quad (2)$$

(2) also shows average power per log(M) bits, since codewords carry log(M) bits of information. For different source distributions, information per codeword will be different from an theoratic information. However, to avoid complexity, we assume each codeword carries log(M) bits of information, leaving the information theoretic analysis to a future study. We have developed MEC by keeping the codeword length unconstrained. Let us investigate the minimum length of MEC.

A. Minimum Codeword Length

n_{min} is the minimum codeword length required to satisfy the MEC weight enumerator for given M and d. n_{min} is important as it gives the minimum delay due to transmission of codewords. $A(n, d, w)$ is the maximum number of codewords have length $n$and having$d$ as code distanceand fixed code weight w.

1. $p_{max} < 0.5$, *d even:* Weight enumerator of MEC is $WC(z) = Mz^{d/2}$. so,

$n_{min} = \min\{n : A(n, d, d/2) \geq M\}$.

because 1*s* in each codeword are not joined
$n_{min} = (Md/2)$

2. $p_{max} < 0.5$, *d odd:* we know that weight enumerator is $WC_i(z) = z^{(d/2)-i} + (M-1)z^{(d/2)}$
1*s* in all the codewords should not be joined with the 1*s* in the codeword having maximum probability, i.e., the codeword having weight $\lceil d/2 \rceil$
Hence,
$n_{min} = \lceil d/2 \rceil + \min\{\tilde{n} : A(\tilde{n}, 2m+1, m+1) \geq M-1\}$,

where $d = 2m+1$. The following property is helpful [15]:

$A(n, 2m-1, w) = A(n, 2m, w)$
$\Rightarrow A(\tilde{n}, 2m+1, m+1) = A(\tilde{n}, 2m+2, m+1)$.(3)

Therefore, min $\{\tilde{n}\} = (m+1)(M-1)$.
Hence, $n_{min} = m + (m+1)(M-1) = \lceil d/2 \rceil M - 1$.

3. $p_{max} > 0.5$: In this case, MEC has the weight enumerator $WC(z) = z0+(M-1)zd$ and maps the all-zero codeword to the source event having maximum probability. Minimum codeword length is found as

$n_{min} = \min\{n : A(n, d, d) \geq M - 1\}$.

In the literature, there is no explicit formulation for $A(n, d, d)$. We can use the existing lower bounds on the code size. From [15],

$A(n, 2m, w) = A(n, 2m-1, w) \geq 1/q^{m-1}\binom{n}{w}$

$$\Rightarrow A(n, d, d) \geq 1/q^{(d/2)-1}\binom{n}{d}, \quad (4)$$

where q is a power such that $q \geq n$.

$$n_{min} = d + (M-2)\lceil d/2 \rceil \quad (5)$$

B. Energy per Information Bit

Next, we obtain energy required per information bit to demonstrate the energy efficiency of our coding scheme. Probability that a codeword is correctly decoded, can also be obtained as follows using law of large numbers:

$$\xi_d \approx \frac{\text{\# of codewords correctly decoded}}{\text{\# of codewords transmitted}} \quad (6)$$

for a large number of transmitted codewords, for a code with distance d. Hence, if Q codewords are transmitted, then $\log(M)Q\xi_d$ bits of information is received. Average energy transmitted per codeword is $EC = P_{sym}E(w)T_{sym}$ joules, where T_{sym} is the symbol duration. Then, the total energy dissipated for Q transmissions is ECQ. Therefore, the average energy per bit is expressed as the ratio

$ECQ/\log(M)Q\xi_d$, i.e.,

ISSN: 2278 – 1323

$$\eta = \frac{E(w)Psym\,Tsym}{\log(M)\xi d} \quad (7)$$

C. Spectral Efficiency

Finally, we investigate spectral efficiency, which is oneof the important parameters in a communication system. It is the ratio of data rate to the bandwidth and yields how efficiently channel bandwidth is utilized. Information transmitted per codeword per second is given by ξd log$M/nTsym$. Bandwidth required per codeword in Hz isgiven by lB. Then spectral efficiency of MEC is obtained as

$$\nu = \frac{\xi d \log(M)}{nlT\,sym\,B} \approx \frac{\xi d \log(M)}{2nl} bps/Hz. \quad (8)$$

VIII. SIMULATION RESULTS

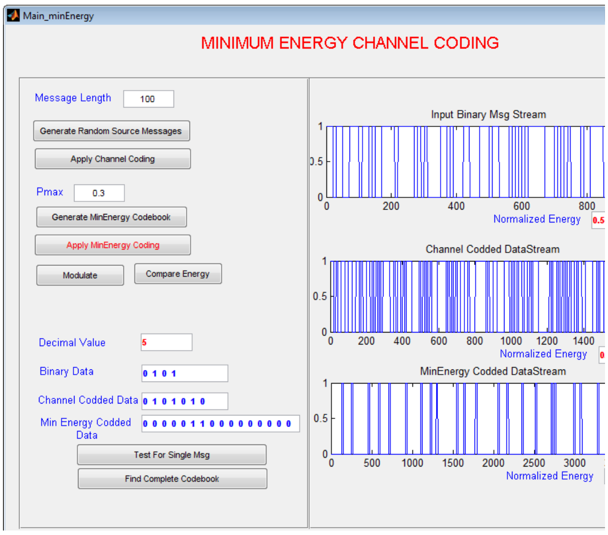

Fig 3. GUI of minimum energy coding(MEC)

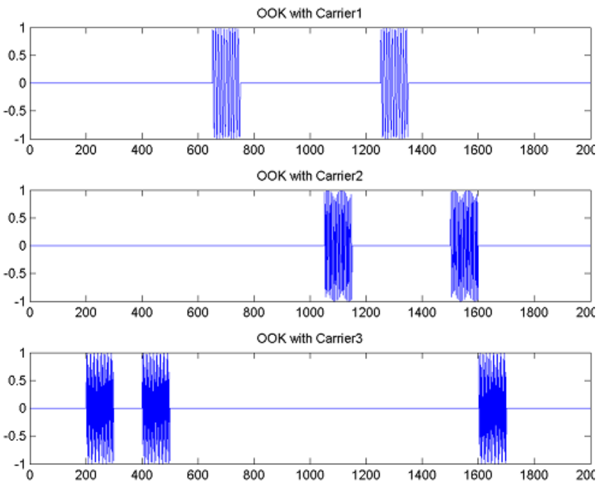

Fig 4. OOK modulation and transmission with different carriers

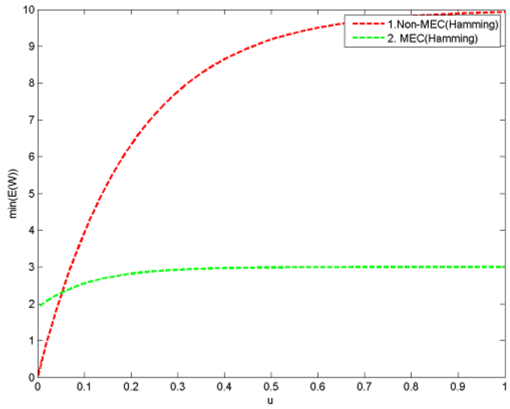

Fig 5. Energy comparison of hamming code and Proposed MEC

IX. CONCLUSION

We proposed a new channel coding technique along with the multicarrier OOK modulation. Minimum energy coding gives the minimum hamming distance and assures reliability.the proposed technique is much efficient and superior to conventional codes like hamming codes. Using OOK modulation the processing power is totally neglected and the results show that minimum energy coding is energy efficient as well as reliable for wireless nanosensor networks in future.

REFERENCES

[1] F. Akyildiz and J. M. Jornet, "Electromagnetic wireless nanosensor. networks," *Nano Commun. Net.*, vol. 1, pp. 3–19, 2010.

[2] G. W. Hanson, "Fundamental transmitting properties of carbon nanotube antennas," *IEEE Trans. Antennas Propag.*, vol. 53, pp. 3426–3435, 2005.

[3] B. Atakan and O. B. Akan, "Carbon nanotube sensor networks," in *2009IEEE NanoCom*.

[4] J. M. Jornet and I. F. Akyildiz, "Channel capacity of electromagnetic nanonetworks in the Terahertz band," in *2010 IEEE ICC*.

[5] C. Erin and H. H. Asada, "Energy optimal codes for wireless communications," in *1999 IEEE CDC*.

[6] M. Kocaoglu and O. B. Akan, "Minimum energy coding for wireless nanosensor networks," in *2012 IEEE INFOCOM*.

[7] M. Kocaoglu and D. Malak, "On the node density limits and rate-delayenergy tradeoffs in ad hoc nanonetworks with minimum energy coding," in *2012 IEEE MoNaCom*.

ISSN: 2278 – 1323

[8] J. M. Jornet and I. F. Akyildiz, "Low-weight channel coding for interference mitigation in electromagnetic nanonetworks in the terahertz band," in *2012 IEEE ICC*.

[9] Y. Prakash and S. K. S. Gupta, "Energy efficient source coding and modulation for wireless applications," in *2003 IEEE WCNC*.

[10] S. Xu *et al.*, "Self-powered nanowire devices," *Nat. Nanotechnol.*, vol. 5, pp. 366–373, 2010.

[11] Y. Huang *et al.*, "Logic gates and computation from assembled nanowire building blocks," *Science*, vol. 294, pp. 1313–1317, 2001.

[12] O. V. Kibis *et al.*, "Generation of terahertz radiation by hot electrons in carbon nanotubes," *Nano Lett.*, vol. 7, pp. 3414–3417, 2007.

[13] I. F. Akyildiz and J. M. Jornet, "The Internet of nano-things," *IEEE Wireless Commun.*, vol. 17, pp. 58–63, 2010.

[14] K. S. Yngvesson *et al.*, "Experimental detection of terahertz radiation in bundles of single wall carbon nanotubes," in *2008 ISSTT*.

[15] F. J. MacWilliams and N. J. A. Sloane, *The Theory of Error-Correcting Codes*. North-Holland, 1977.

Prof. Anuradha S. Deshpande,BE ECE, ME Electronics. She is an Assistant Professor at JSPM's ICOER. She published "DWT based satellite color image resolution enhancement" Vol. 3 Issue 2 in IJMER

Mahesh Adhav, Student of BE ECE at JSPM's ICOER, Pune.

Prashant Khati, Student of BE ECE at JSPM's ICOER, Pune.

Shekhar Zende, Student of BE ECE at JSPM's ICOER, Pune.

ISSN: 2278 – 1323