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Development of DBEA Compressed Data Transfer System over Power Line

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Abstract

Data transfer is extremely important in any Data Acquisition System (DAS). Power system operation involves enormous volume of data transfer between field devices (or generating stations) and data centre (or Load Despatch Centre). Data compression is an extremely popular in communication as there is a reduced energy requirement for transferring compressed information. Power line communication is still in operation for data transfer between different substations and Differential Code Shift Keying (DCSK) modulation scheme is extremely popular in the majority of the available power line communication modems. Differential Binary Encoding Algorithm (DBEA) is a low computational approach which can give high compression ratio with repetitive slow varying data array. As majority of available data can be compressed successfully, this work focuses on the development of DBEA compressed data transfer system suitable to transfer data over power line. At the encoding end, a large data array corresponding to different practical data is compressed by DBEA before transferring the string through DCSK. From the superchirp being obtained, compressed string is extracted and is decoded to obtain actual data array at decoding end. As DBEA is implemented and tested successfully at low level microcontrollers, it is possible to extend this work for practical applications.

Key words

Differential Binary Encoding Algorithm (DBEA), Differential Code Shift Keying (DCSK), Power Line Carrier Communication (PLCC), Power System Operation, Data Compression, Chirp.

1. Introduction

The transfer of data over power line, i.e. Power Line Carrier Communication (PLCC) is still in operation in electrical power system. Some of the existing communication schemes employed for data transfer between field devices and data centre includes PLCC, Microwave and optical fibre communication. Remote Terminal Units (RTUs) are responsible for acquiring this data and transferring this information through suitable communication channel. Generation of different generating stations (GS), direction and amount of power flow in the circuit connected between the substations or between a substation and a plant, bus voltage, system frequency etc. are monitored regularly. These readings are displayed in the Human Machine Interfaces (HMIs) present in the control room of Load Despatch Centres (LDC) and are updated regularly typically at every 8-10 sec. It implies that an extremely large database is required for storing all this information which are maintained by the LDCs. Data compression will a good choice to handle this large volume of data which can reduce the memory requirement significantly. As data compression will result in reduced data volume which implies that reduced energy will be required to transmit a given volume of data over a suitable communication channel [1].

As different parameters associated with electrical system are related, it is possible to understand the system health condition by continuous monitoring of a system. In late 90s, the system frequency variation was permissible within ±5% of standard system frequency. Though the system frequency variation was within 48.5- 51.5 according to new regulation, but it is generally maintained between 49.5- 50.2 Hz to avoid Unscheduled Interchange (UI) charges. Availability Based Tariff (ABT) is a modern tariff structure started from 2002-2003 which reduces the non-availability or frequent disruption of the power plants significantly. As system frequency and active power balance are proportion, frequency near to rated system frequency is possible only when over drawal or under drawal of the power drawn by the distribution companies (or GS) beyond their allotment will reduce. This is achieved by introducing UI charges in ABT. But, the computation of these UI charges is only possible if system parameters i.e. active and reactive power, system frequency etc. are monitored continuously. This implies that DAS is the heart of any stable electrical power system and significant volume of data transfer occurs between field devices and data centre [2-5].

PLCC, as the name suggests, is a method of communication through power line. Every house and building has properly installed electricity lines which if can be used for data transfer; it becomes easy to connect the houses with a high speed network access point thereby eliminating the need of Ethernet cable. Though microwave and optical fibre with high data transfer rate are introduced for power system monitoring, PLCC technology is still operation in few lines.

Conventional modulation techniques are not suitable for power line environment due to the presence of high and low frequency noise in the line. With the significant increase in the use of power electronic devices, the amount of noise injected in the line will increase. To overcome the problem, a new modulation technique, Differential Code Shift Keying (DCSK) was developed and patented by Yitran Technology in 2000. It is modified version of spread spectrum technology where the data is transmitted in terms of cyclic shifting of any suitable spreading waveform. It is a highly robust communication scheme in power line environment and many PLCC modems are based on this modulation scheme [6-9]. In [6], this DCSK modulation scheme is developed in MATLAB environment where the superchirp corresponds to a character string is obtained at the encoding end. At the decoding end, character string is decoded from the superchirp. Different entropy based compression algorithms (Basic Arithmetic Coding and Huffman Coding) are developed to compress the string and transmit the superchirp containing reduced number of chirps. In [7], the results obtained by the original algorithm and algorithms using entropy based compression are compared to determine the advantages and disadvantages of each algorithm.

Compression of power system parameters or waveform can be of great importance while approaching towards the formation of smart grid. Two data sets of fault data for high voltage (HV) lines and half-hourly electrical load readings for customers were investigated in [10] using data mining techniques. In [11], real system data (voltage, frequency, MW and VAR generation, system demand) is analyzed to find interrelation between several system parameters. The recorded data was collected from Southern Regional Load Despatch Centre (SRLDC). Four schemes based on four variants of the arithmetic coding are proposed in [12] and is based on the fact that steady state power system data exhibits a high degree of correlation between consecutive measurement values. The hourly data is compressed by the four algorithms to achieve the results and it was indicated that the compression ratio varies over a wide range. For smart metering application, a linear time complexity lossless algorithm, Resumable Load data compression algorithm (RLDA) is developed in [13] and gives satisfactory performance with majority of data array. In this algorithm, differential coding is followed by zeroth order signed exponential-Golomb coding and Basic Arithmetic Coding based compression to achieve the compression ratio of about 40. A highly efficient lossy data compression is designed in [14] to store key information of load features and is termed as feature-based load data compression (FLDC). This will reduce the great burden on data transmittance, storage, processing, application, etc and increases compression ratio to 55.

A novel compression approach is developed in [15] which utilize the repetitive property of the data values to compress a large data array to an encrypted character string. The algorithm, Differential Binary Encoding Algorithm (DBEA) gives extremely high compression ratio for higher repetition in the data array to be compressed and lesser computation required for executing the algorithm. A high compression ratio is achieved with majority of parameter monitoring and unit commitment data. A software based ECG data compression algorithm (LLEDCCE) is proposed in [16] and a compression ratio of 7.18 is obtained. EDCCE [17] is the other lossless ECG data compression algorithm where the compression ratio increases to 15.72. Though DBEA, LLEDCCE and EDCCE are computationally similar, DBEA have much reduced computation and gives much higher compression ratio.

The entropy based algorithms discussed in [7] can achieve a low compression ratio (3<). This encourages the development of DBEA compressed data string transfer scheme for power line environment. At the encoding end, a large parameter monitoring or unit commitment data array is compressed by DBEA to obtain the character string. Based on this compressed string, the corresponding superchirp can be obtained. At the decoding end, encrypted string is extracted from the superchirp by comparing it with non-shifted chirp waveform. This encrypted string is then decoded by DBEA to obtain the actual data array as given in the block diagram in Figure 1.

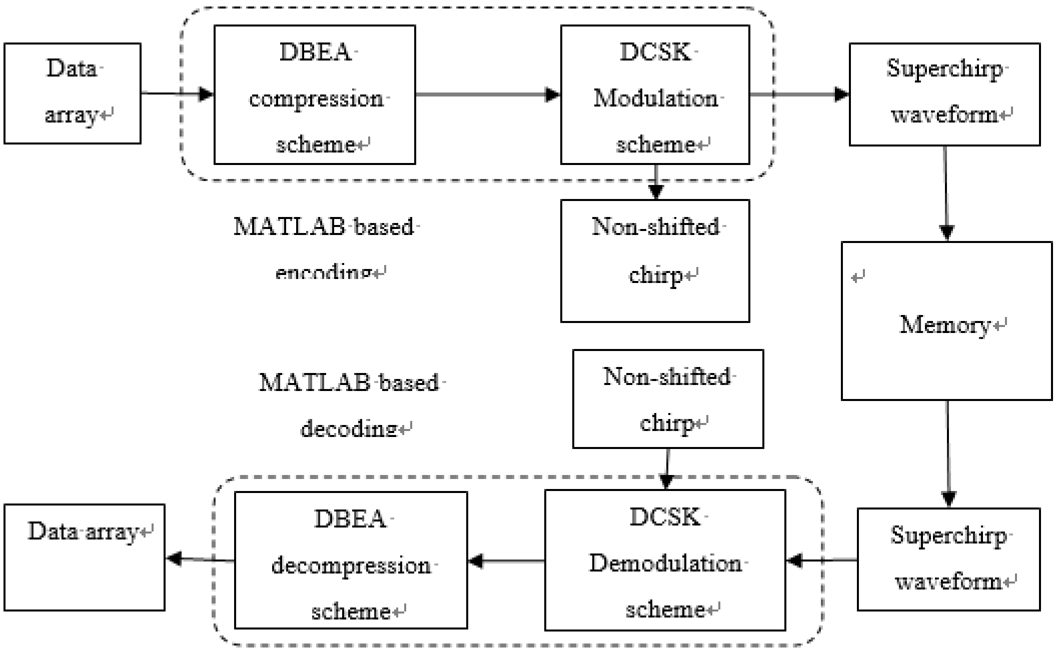


Fig. 1. Block diagram of proposed system

2. Power System Operation and Practical Data Analysis

In India, Power System Operation Corporation Ltd (POSOCO), a wholly owned subsidiary of the Power Grid Corporation of India Limited (a Government Company) formed in March 2010 is responsible for handling the power management functions and operate 5 Regional Load

Despatch Centres (RLDCs) under the belt of National Load Despatch Centre (NLDC) [1]. Apart from these, several state LDCs (SLDCs) comprising of one or multiple Sub-LDC assists the respective RLDC. Supervision of RLDC is among the primary role of NLDC. It is responsible for electricity scheduling and despatch over inter-regional links maintaining grid standards in coordination with RLDCs. Maximum economy and efficiency of national grid is also obtained by proper coordination with RLDCs. Energy accounting of inter-regional power exchange is also done by it by proper coordination with RLDCs. It also coordinates for trans-national power exchange. It monitors the operation and grid security of national grid.

RLDC ensures the integrated operation of power system in the concerned region. It is responsible for optimum electricity scheduling and despatch within the region after maintaining the necessary contacts with the licensees and generating companies working in that region through the respective SLDCs. Account keeping of power quality transmitted by the regional grid is done by it. RLDC is responsible for supervision and control of inter-state transmission system. Scheduling / Re-scheduling of generation for National power stations are performed by it. Similarly, SLDC will ensure the integrated operation of power system in the concerned state. It is also responsible for optimum electricity scheduling and dispatch within the state after maintaining the necessary contacts with the licensees and generating companies working in that state through the respective sub-LDCs. Supervision and control of intra-state transmission system is done by SLDC. Grid operation monitoring is also among the responsibilities of RLDC and SLDC.

It is a fact that various parameters associated with power system are interrelated. Any unbalance in active power of the system will result in the variation of system frequency. But variation in system voltage may occur when any unbalance in reactive power occurs. It implies that parameter monitoring is very crucial for power system operation. Accurate load forecasting and generation scheduling can reduce the unbalance to quite some extent. The responsibilities assigned to LDC clearly indicate that they are responsible to maintaining system stability. Conventional SCADA can acquire various parameters regularly at every 5 second or so and the data is stored in the data centre. Hourly variation of generation data of a thermal and hydel generating station (GS), power delivered by a 220kV line and system frequency for an entire day is given in Figure 2.

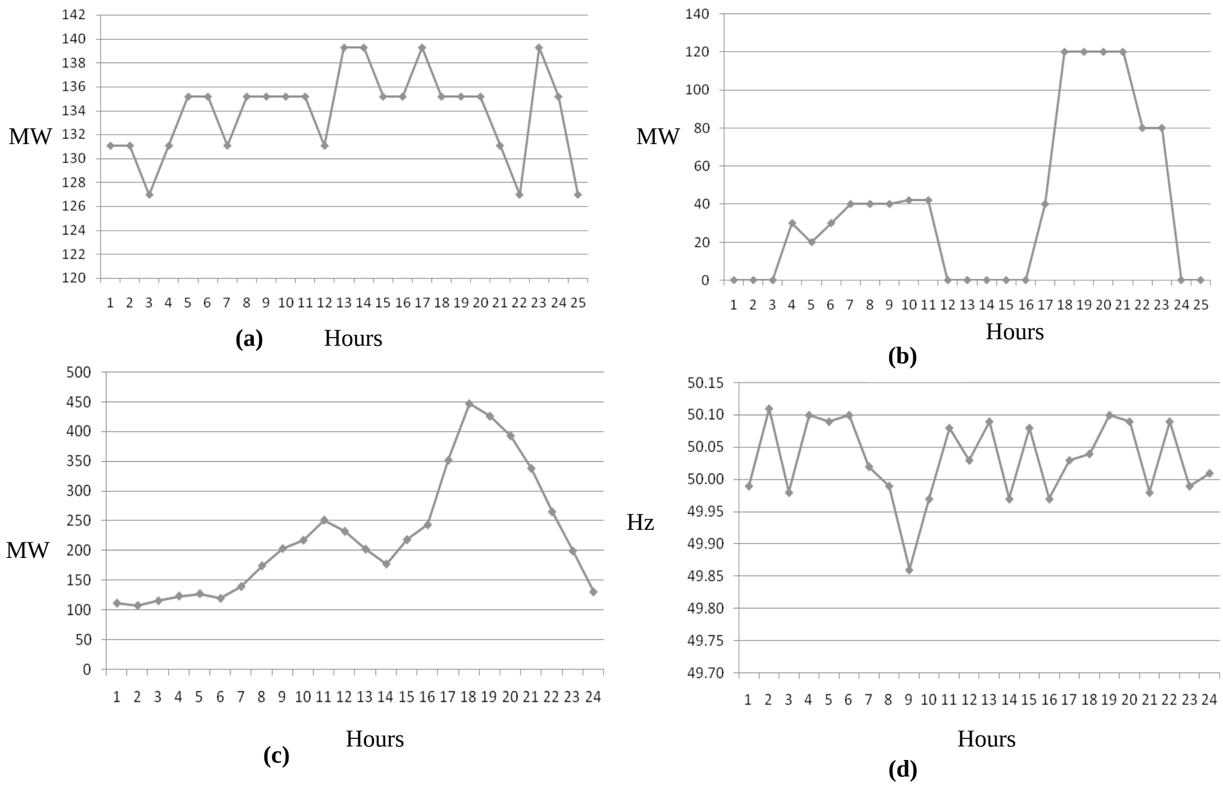


Fig. 1. Hourly variation of system parameters over a day: (a) MW generation of a thermal GS; (b) MW generation of a hydel GS; (c) MW transferred by a 220kV line and (d) System frequency

It is clearly visible from Figure 2 that the rate of variation of system parameters is low for majority of parameters. It is also observed that any parameter monitoring data is very repetitive in nature. In case of any variation under stable condition, the difference between the consecutive readings will be within a small range. There can be any abrupt change only if some fault occurs in the system. From the previous discussions, it is clear that over-drawal or under-drawal of power from the grid will results in variation of system frequency which is highly undesirable. Conventional one part or two part tariff can’t limit this problem and thus a new tariff scheme, Availability Based Tariff (ABT) had evolved. This tariff was implemented in 2002-2003 and is in operation till now. The main objective of the tariff is to improve the efficiency of generating plants as the fixed cost will be provided only if the plant availability is found. ABT can be considered as a 3-part tariff involving fixed charge, energy charge and unscheduled interchange (UI) charge. The capacity or fixed chart of a plant is computed after considering interest on the lone and working capital, depreciation of the equipments, return on equity and operational and maintenance expenses including insurance [15, 18].

Energy charge includes the fuel cost of the energy fed to the buses which is lower than that being generated as the remaining energy is used to run plant auxiliaries. Both generating stations and distribution companies prepare their schedule in advance for 96 time blocks and submit the information to the corresponding LDC. If due to some faulty calculation of load forecasting or tripping of one or multiple alternators, there might have some over-drawal or under-drawal thereby violating the schedule. Unscheduled interchange in a particular time block can be defined as the difference between total actual generation and total scheduled generation for a generating station or a seller and the difference between total actual drawal and total scheduled drawal for a beneficiary or a buyer. The penalty or reward for this unscheduled interchange is termed as unscheduled interchange charge and is based on the average frequency of the time block [15, 18]. The analysis of unit commitment information of six different thermal GS operating under WBPDCL for 159 days during March 2015 and February 2016 gives some interesting observations which are as discussed below [19].

a. For 4.5% of the available data, all the elements of unit commitment data are identical.
b. For 21.5% of the available data, the difference between maximum and minimum generation is between 11 and 30 MW. For 76.7% the available data, the difference is within 100MW.
c. Due to ramp up or ramp down constraint of alternator, the load is increased or decreased in a few discrete steps.

3. DBEA Compression Scheme

DBEA is differential coding based approach and is functionally similar to some algorithms available for compressing ECG data array [16, 17]. It can compress majority of monitoring or unit commitment data array successfully to an encrypted character string. In Differential Coding, difference array dif [n] is obtained from actual array act[n] such that dif[i] will be act[i], for i= 0 and (act[i]- act[i-1]), for 0< i < n. It is obvious that, for a repetitive array, the elements of difference array will have large number of zeros. In order to eliminate the zero values, consecutive zeros are replaced by their count to form a modified array having m number of elements (m< n). The elements of modified array, mod[m] can be classified under four categories as [15]:

a. First element: The first element, mod [1] will be same as the act [1].
b. Zero count: The number of consecutive zeros is encoded by adding identity bit ‘0’.
c. Positive difference: The positive difference is encoded by adding identity bit ‘10’.
d. Negative difference: The negative difference is encoded by adding identity bit ‘11’.

The total number of positive and negative counts in the modified array is termed as number of changes. Based on modified array element category, binary coding of the elements is performed. The binary equivalents of the elements are added with identity bits (as required) in binary encoding section. The 16-bit first element is divided in two 8-bit binary values and the decimal equivalent of the binary is stored in the first two consecutive positions of ASCII value array, asci []. The 8-bit binary equivalent of zero count, positive and negative difference are also converted to corresponding decimal equivalent and is placed in the respective position in asci[]. The character equivalent of (m+1) numbers of elements of asci[i] are concatenated together to form the encrypted character string, str. The steps followed in DBEA compression scheme is illustrated with an example in Figure 3. The decoding is done by following the reverse order.

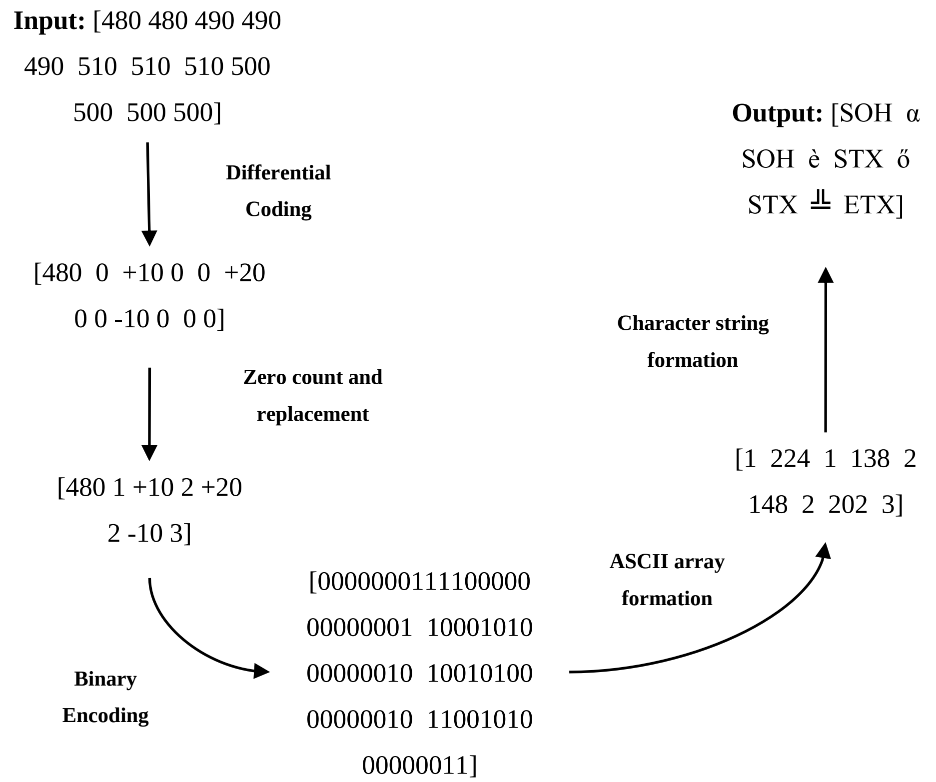


Fig. 2. Compression of data array to a character string by employing DBEA algorithm

4. DCSK Communication Scheme for PLCC

Differential Code Shift Keying (DCSK), a modified version of spread spectrum communication, was developed particularly for power line communication scheme. It modulates any symbol by cyclic shifting of the basic symbol at the transmitter end. The amount of shift is detected at the receiver end by comparing it with a non-shifted reference waveform. DCSK modulation scheme can be illustrated by using a ramp waveform subdivided in ten parts. For transmitting symbol ‘4’, the actual waveform is shifted counter clockwise by four units respectively as illustrated in Figure 4. Some of the advantages of this DCSK modulation scheme includes higher transmission reliability, fast and simple synchronization, immediate recovery after severe fading and higher data throughput rate [6-8].

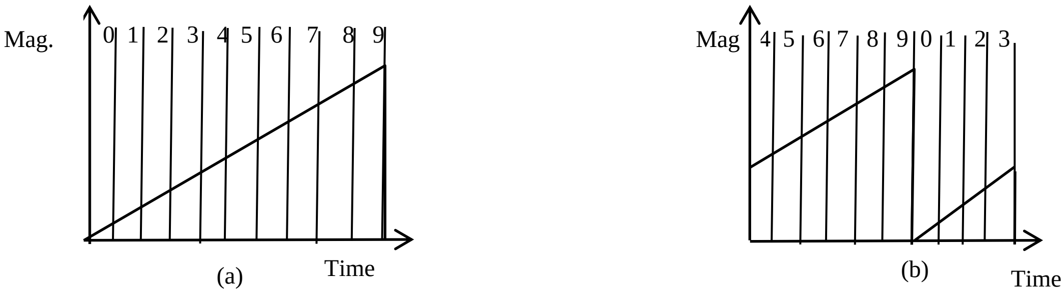


Fig. 3. Simple illustration of DCSK modulation scheme (a) Non- shifted waveform; (b) Waveform for transmitting symbol ‘4’

The waveform required to perform DCSK modulation can be any waveform having suitable auto correlation properties and chirp waveform is most commonly employed. These chirp waveforms are frequency modulated signal of constant length which is rotated suitably depending on the data value. This rotated chirp waveforms are termed as ‘Unit Symbol Time’ (UST). There are two alternatives for designing this system. In the first arrangement, the data is conveyed in the amount of rotation of the individual chirp. Alternatively, data may be conveyed in the differential shift between two consecutive chirps. The first case is considered in this case owing to its simplicity. A non-shifted chirp waveform and a shifted chirp waveform (UST) are given in Figure 5. At the receiving end, the received waveform is compared with the non-shifted waveform to determine the extent of rotation. This is done by a series of rotation of received waveform and simultaneous comparisons with the non-shifted waveform. For transmitting a string with n characters using DCSK modulation scheme, the corresponding superchirp will be a combination of n shifted chirp waveforms (USTs). At the receiving end, the superchirp is divided in individual USTs which are then compared with the reference non-shifted chirp waveform to decode the number array. Figure 5 (c) gives a superchirp waveform comprising of four USTs and the arrow indicates the extent of rotation of individual USTs. If d be the number of significant digits of final frequency (ff), fi be the initial frequency and D be the number of divisions of the chirp waveform, sampling time (tdel) and UST length (tf) of the waveform can be calculated by equation (1) and (2) [6-8].

$$tdel = 10^{-(d+2)} \text{ sec} \quad (1)$$

$$tf = (D * t' - tdel) \text{ sec, where } t' = 1/(ff - fi) \quad (2)$$

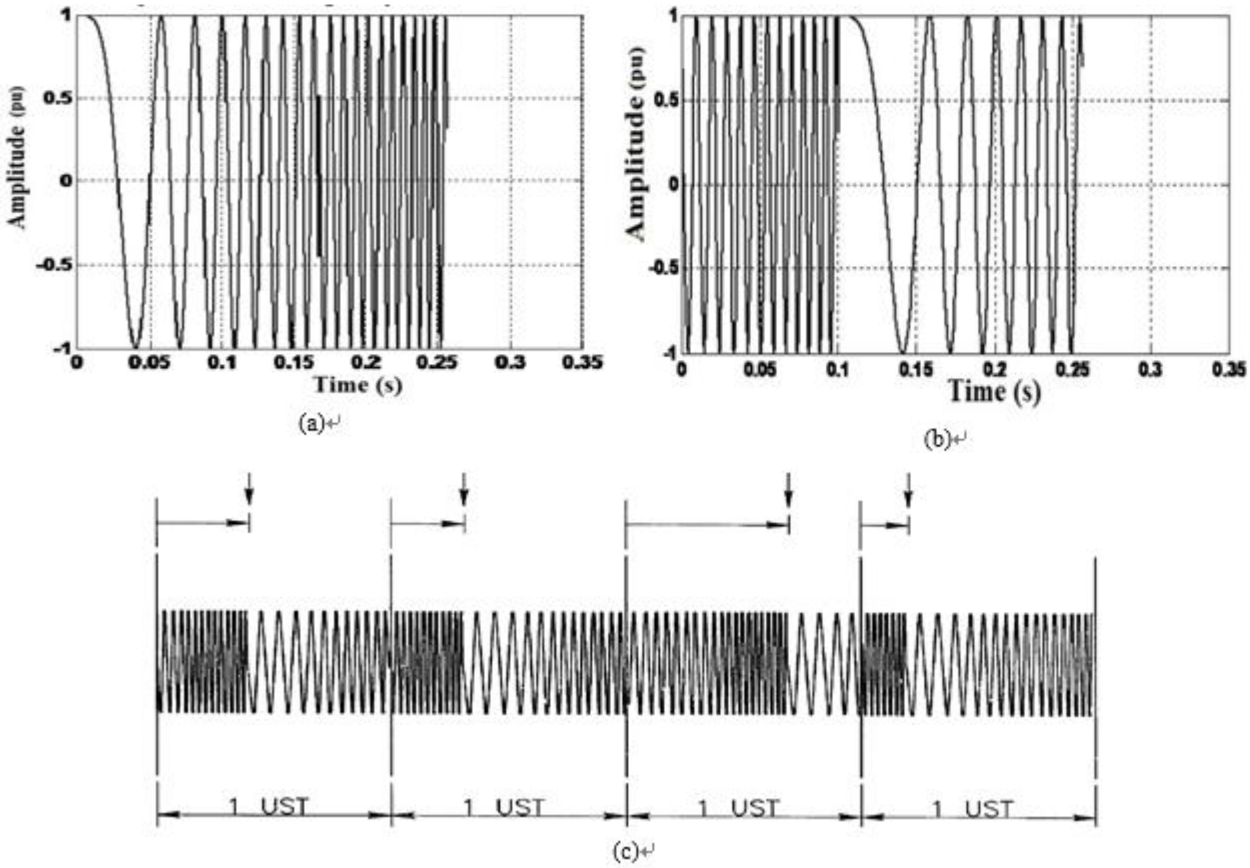


Fig. 5. Chirp waveform based DCSK: (a) Non-shifted chirp; (b) Clockwise shifted chirp and (c) Superchirp

5. DCSK based Compressed Data Transfer

Implementation of DBEA for compressing unit commitment and parameter monitoring data gives good results for majority of data. Power Line Communication is still in operation for data transfer in power system application. A DBEA compressed data transfer scheme employing DCSK communication scheme is developed and tested offline in MATLAB environment. At the encoding end, a large data array associated with parameter monitoring data is compressed to a character string by using DBEA. The superchirp corresponds to this character sting is obtained which can be transmitted over power line. This superchirp and reference chirp being obtained is stored in the computer for decoding purpose. At decoding end, actual character string is obtained after splitting the superchirp to individual chirp and is compared with the reference non-shifted waveform to extract the information contained in it. Actual array is the then decoded from the compressed information by using DBEA scheme. The algorithm being employed at encoding end is given below.

Input:

arr[l]: Array of length l to be compressed by DBEA; fi: Initial frequency of chirp waveform; ff: Final frequency of chirp waveform

Output:

s(t): Superchirp with n USTs; r(t): Reference non-shifted chirp

STEP 1: Perform the differential coded array dif[l] corresponds to arr[l].

STEP 2: The consecutive zeros are counted and are replaced to form modified array, mod[m] (m< l).

STEP 3: bin:= 16 bit binary corresponds to mod[1].

STEP 4: bin is divided to 2 8-bit binary values, bin1 and bin2.

STEP 5: Determine the decimal equivalent of bin1 and store the result in asci[1]. Similarly, the decimal equivalent of bin2 is stored in asci[2].

STEP 6: Initialize i:=2 and repeat steps 7-9 until i> m.

STEP 7: : Perform the binary encoding of mod[i] and determine the decimal equivalent (dec) of 8-bit binary value.

STEP 8: : asci[i+1]:= dec.

STEP 9: : Increment i by 1.

STEP 10: End of the loop.

STEP 11: Based on fi and ff, r(t) is produced. Define s(t)= NULL.

STEP 12: Initialize i:= 0 and repeat steps 13-15 until i> m.

STEP 13: : Rotate r(t) counter clockwise (or clockwise) according to asci [i] to form UST.

STEP 14: : s(t):= Merge UST with s(t).

STEP 15: : Increment i by 1.

STEP 16: End of the loop.

STEP 17: End.

The algorithm being employed at decoding end to obtain actual data array from superchirp is given below.

Input:

s(t): Superchirp containing n USTs; r(t): Non-shifted reference chirp

Output:

act [n]: Decoded data array having n elements

STEP 1: Comparing s(t) and r(t), value of n cal be calculated.

STEP 2: Define ASCII value array asci[n]. Initialize i:= 0 and repeat steps 3- 5 until i< n.

STEP 3: : Obtain (i+1)th UST and initialize cnt:= 0.

STEP 4: : Rotate UST clockwise (or counter clockwise) by 1 unit and compare with r(t). If both are not identical cnt:= cnt+1, else asci[i]= cnt.

STEP 5: : Increment i by 1.

STEP 6: End of loop

STEP 7: Form the ASCII value array, asci[n] containing the ASCII value of the characters contained in str.

STEP 8: The first element of modified array, modi[1]:= 256*asci[1]+ asci[2].

STEP 9: Initialize i:=3 and repeat steps 10-12 until i> n.

STEP 10: : x:= asci[i]

STEP 11: : If x< 128, modi[i-1] will be zero count and the element will be x.

Else if x> 192, modi[i-1] will be negative difference and the element will be (192- x).

Else, modi[i-1] will be positive difference and the element will be (x-128).

STEP 12: : Increment i by 1.

STEP 13: End of the loop.

STEP 14: The first element of difference array, dif[1]:= modi[1].

STEP 15: Initialize j:= 2, cnt:= 2 and repeat step 16 until j> n-1.

STEP 16: : If modi[j] is positive or negative difference, dif[j]= modi[j]. j:= j+1. cnt:= cnt+1.

For modi[j] be zero count, dif[j] to dif[j+ modi[j]] will be zero. j:= j+1. cnt:= cnt+ modi[j].

STEP 17: End of the loop.

STEP 18: act[1]:= dif[1] and act[i]:= dif[i]+ dif[i-1] for 1< i< cnt.

STEP 19: End.

6. Results and Analysis

DBEA is a lossless compression algorithm which implies that there is no loss of information during the encryption. Compression ratio (CR) i.e. the ratio of input and output memory requirement is a crucial parameter for any compression algorithm. It is obvious that higher will be the compression ratio, better will be the algorithm. Generally compression ratio achieved by any lossy compression technique is higher than that obtained by any lossless compression algorithm. The results obtained by DBEA are satisfactory for both parameter monitoring and unit commitment data. The compression ratio varies over a wide range owing to the fact that compression ratio varies exponentially with the number of changes in the data array. This implies that the length of superchirp and hence the number of USTs required to form the superchirp varies with the data array. The example of the sample array considered in Section 3 will have nine characters in the encrypted character string. While executing the proposed algorithm in MATLAB, the superchirp corresponds to the compressed character string will have nine USTs in it. Superchirp corresponds to the character string will initial and final frequency 0 Hz and 1 kHz will be as given in Figure 6.

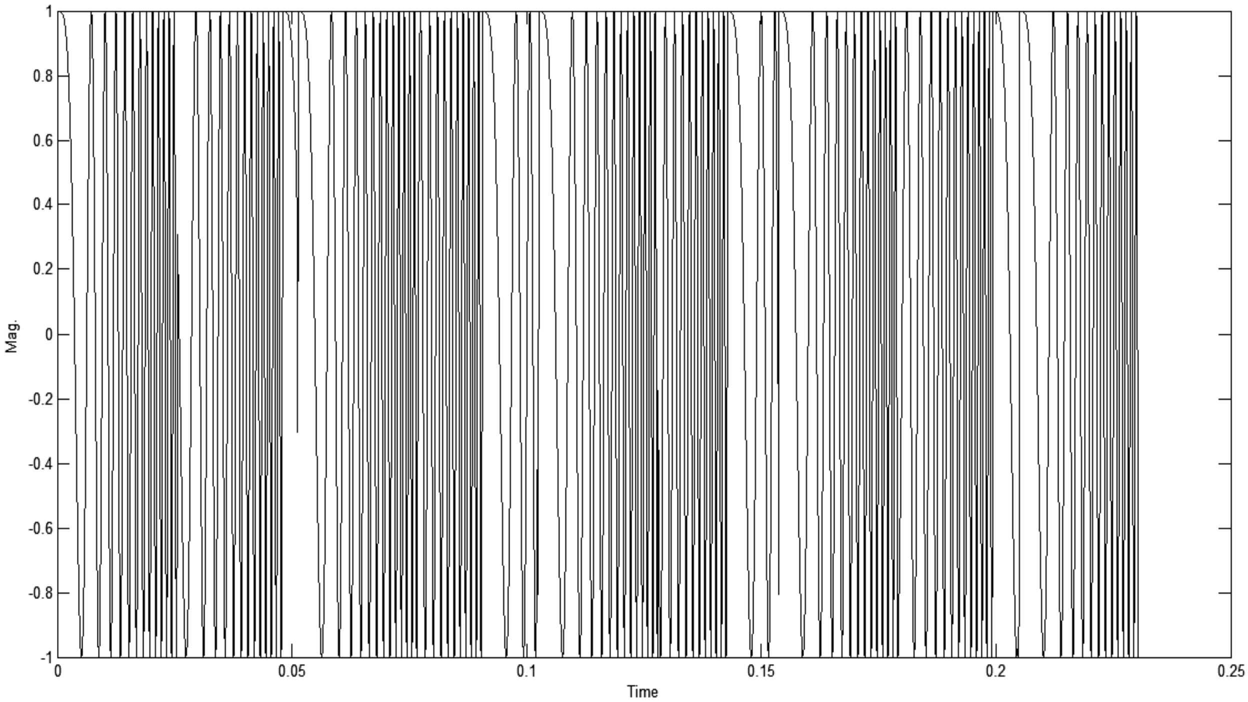
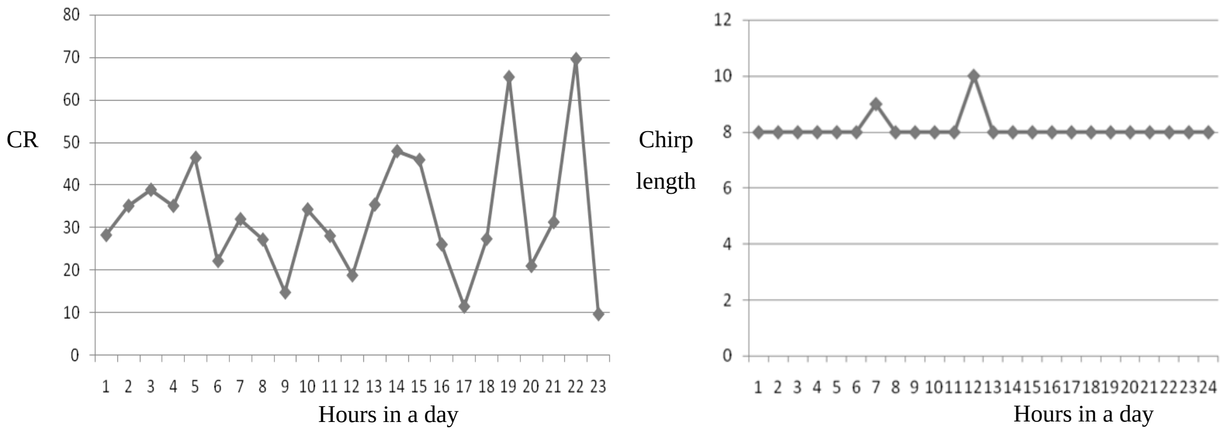


Fig. 6. Superchirp corresponds to the character string obtained by compressing sample data array by DBEA. Initial and final frequencies are 0 Hz and 1 kHz respectively

Tab. 1. Performance analysis for practical unit commitment data

Sl. No.	Date	Name of GS	CR	No. of UST
1	06/03/2015	BTPS	15.93	14
2	24/03/2015	STPS	96	3
3	17/04/2015	KTPS	32	8
4	20/05/2015	STPS	15.16	28
5	28/05/2015	BkTPP (1 to 3)	48	5
6	02/06/2015	SgTPP	18	16
7	09/06/2015	BkTPP (4 and 5)	28.8	10
8	13/06/2015	SgTPP	13.1	26
9	22/07/2016	NTPC, Barh	72	8
10	23/07/2016	NTPC, Barh	24	15
11	24/07/2016	NTPC, Barh	72	7
12	25/07/2016	NTPC, Barh	72	8
13	26/07/2016	NTPC, Barh	72	8
14	27/07/2016	NTPC, Barh	72	8
15	28/07/2016	NTPC, Barh	48	10



(a) (b)

Fig. 7. Variation of (a) Compression ratio of power transfer data through a 400kV line and (b) Chirp length for hourly generation data of a Hydel GS

The unit commitment information of Barh super thermal GS over a week [20] are compressed by DBEA and the corresponding superchirps were obtained by DCSK based communication scheme. Few unit commitment information data of GS operating under West Bengal Power Development Corporation Limited (WBPDCL) [19] are also compressed and the corresponding superchirp is obtained. The compression ratio and number of USTs in the superchirp being obtained for those data samples is given in Table 1. It is clear from the figure that higher will be the number of USTs in the superchirp, lower will be the compression ratio and vice versa. With increased number of changes in the data array, the number of characters in the encrypted string will increase thereby increasing the number of USTs and reducing the compression ratio.

From the previous discussions, it clear that DBEA based DCSK scheme is giving pretty good result when there is a huge repetition of data is encountered. In order to avoid any additional or reduced drawal to avoid the UI charges, both GS and transmission companies tends to stick on its forecasted drawal conditions. This implies that the parameter monitoring data do not vary extensively with time and thus DBEA based compression can give pretty good compression ratio for majority of the testing data obtained from WBSLDC. The hourly data associated with data transferred through a 400kV line and generation data of a hydel generating station over an entire day is compressed by DBEA. The variation of compression ratio (CR) obtained with hourly power transfer data over the day is given in Figure 7 (a). Figure 7 (b) gives the variation of the number of USTs in the superchirp obtained while compressing hourly generation data by DBEA. DBEA compression scheme gives higher CR with repetitive data array. From Figure 2 (b) and (c), it is clearly visible that power transfer data varies over a much higher range in comparison to hydel generation data. So, repetition in power transfer data is lower and thereby lower compression ratio is obtained. Due to high repetition in hydel generation data, superchirp length will much smaller in comparison to power transfer data.

While approaching towards the formation of smart grid, communication and data management plays an important role. The tested results were encouraging and high CR can be achieved by it. For smart metering, a lossless compression algorithm based on Differential Coding, Golomb's coding and Binary Arithmetic coding gives a CR close to 40 for load profile data [13]. For same compressing similar set of data, a lossy compression technique exacting load feature is developed which gives higher CR (>60) [14]. Generally entropy based algorithm are complicated and introduces higher computational burden on the system. DBEA, in contrast can be embedded in low level microcontrollers due to much reduced computational burden. Though the CR achieved by DBEA varies over a wide range, generally this value is above 20 for majority of tested samples. As discussed previously, a few non- entropy based ECG data array compression schemes are available in the literature [16, 17] which can compress an ECG data array to a character string. It implies that the nature of DBEA is similar to those algorithms and thus the properties of those algorithms were compared with DBEA. The comparative results are as given in Table 2.

Tab. 2. Comparison between DBEA and other similar algorithms

Sl. No.	Property	LLEDCCE [16]	EDCCE [17]	DBEA [15]
1	Type of compression	Lossless	Lossless	Lossless
2	Software testing	C- Language	C- Language	C- Language, MATLAB, Arduino IDE
3	CR achieved	7.18	15.72	> 20 (approx.)
4	Hardware testing	-	-	Tested at Arduino UNO with sample data array
5	Future scope	In portable and mobile ECG data monitoring system	In portable and mobile ECG data monitoring system	Development of compressed DAS and monitoring system

DBEA based DCSK communication scheme is developed in MATLAB environment and tested offline. The obtained result clearly indicates that DBEA reduces the volume of data significantly and thereby there is a significant reduction in the number of USTs required to carry the information. As the execution time increases with string length [6], large highly repetitive data array like generation data of hydel plants will have a lower execution time in comparison to large less repetitive data array like power transfer data. Though the paper discusses the development of a software based DAS for power line environment, simplicity of the compression algorithm enables its implementation at hardware level to develop a DAS using any wired or wireless communication technology. Though DBEA gives successful result for majority of the available data, it may fail when the difference between the consecutive elements is greater than 63. In such cases, algorithm must be modified suitably. For non repetitive data array, the performance of DBEA may be poor, but the simplicity of DBEA makes it suitable for lower level microcontrollers. This will result in reduced energy requirement for transmitting monitoring data. As PLCC is still in operation, such a compressed DAS can be realized by embedded modules or existing SCADA network**.**

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