

DSI3 Sensor to Master Decoder using Symbol Pattern Recognition

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ABSTRACT

The newly released Distributed System Interface 3 (DSI3) Bus Standard specification defines three modulation levels from which 16 valid symbols are coded. This complex structure is best decoded with symbol pattern recognition. This paper proposes a simplification of the correlation score calculation that sharply reduces the required number of operations. Additionally, the paper describes how the pattern recognition is achieved using correlation scores and a decoding algorithm. The performance of this method is demonstrated by mean of simulations with different load models between the master and the sensors and varying noise injection on the channel. We prove that the pattern recognition can decode symbols without any error for up to 24dBm.

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1. INTRODUCTION

DSI3 Bus Standard specification [1] is promoted by the DSI consortium. DSI3 goals are to improve performance, reduce cost and promote open standard. Higher performance is achieved among others, by increased communication speed from the slave sensor to the master. The higher communication speed is achieved by compressed bit encoding.

This paper proposes a method for decoding the DSI3 slave to master encoding. Each incoming DSI3 symbol is compared to 16 reference patterns. The comparison consists in calculating correlation scores between the incoming samples and each reference pattern. I propose a simplification of the correlation score calculation. This simplification takes advantage of the fact that the reference pattern stays constant for several consecutive samples. Additionally, the paper proposes an algorithm that takes as input all the correlation scores and chooses one reference pattern as being the encoded data.

The peak correlation allows for inherent sensor clock recovery and adaptation. The master adapts its expected symbol duration to the transmitted symbol duration.

The performance of the proposed method is checked with a Matlab simulation. Noise is injected for several load models between the master and the sensors on the channel. Depending on the load models the decoder manages to decode without error with noise injection from 12dBm up to 24dBm.

The organization of the paper is as follow: [Section 2](#) describes the DSI3 bit encoding. [Section 3](#) describes existing pattern recognitions done in telecommunication protocols. [Section 4](#)

defines how each reference pattern is compared to the incoming symbol. [Section 5](#) defines how a reference pattern is selected based on the correlation score. [Section 6](#) shows the performance achieved with the proposed method. [Section 7](#) summarizes the paper.

2. BACKGROUND

The sensor slave encodes response frames to the master with current modulation. The master supplies the slaves with a quiescent current. The slave modulates this current in a way that the master has to supply a higher current during data modulation. The DSI3 standard defines three current modulation levels:

- 0: this current level is identical to the quiescent current supplied by the master,
- 1: this current level is I_{RESP} above the quiescent current,
- 2: this current level is $2I_{RESP}$ above the quiescent current.

The smallest chunk of information is called *chip*, which represents one current level. The minimum duration during which the slave keeps the modulated current at the same level during data transmission is t_{chip} .

Three chips are combined to form a *symbol*. The slave encodes four bits of data in a symbol. An example of such a coding is given in [Fig. 1](#) and the complete coding table for the valid symbols is given in [Table 1](#).

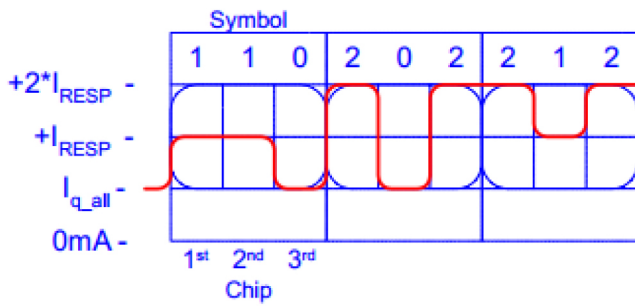


Figure 1. Coding example.

Table 1. Data to symbol mapping

Data	1st chip	2nd chip	3rd chip
0	1	1	0
1	2	1	1
2	1	0	2
3	2	0	2
4	1	0	0
5	2	1	2
6	1	1	2
7	2	0	1
8	2	2	0
9	2	1	0
10	1	2	2
11	2	2	1
12	1	2	0
13	2	0	0
14	1	0	1
15	1	2	1

3. PRIOR ART

Pattern detection using correlation is used very often in telecommunication protocols, but is new to DSI3 Automotive applications.

The Global Positioning System (GPS) Coarse Acquisition Code, defined in [3], is a 1023 bit deterministic sequence. Each satellite transmitter has its own fixed sequence that is highly orthogonal to the other satellites sequence. The receiver can then synchronize to a given satellite by correlating between all references it has and the incoming signal.

The Wireless Local Area Network (WLAN) Preamble starts with 10 short identical symbols, as defined in [4]. The receiver performs auto-correlation which consists in correlating symbol i with the previous symbols. The previous symbols are averaged and compared to the i^{th} symbol. The correlation score is then

accumulated until the last symbol is reached. The receiver then decides to go on with frame reception if the correlation score is high enough.

The CDMA2000 Mobile Technology Standard (part of the 3G mobile family) defined in [5] uses Code Division Multiple Access (CDMA). Each user in a CDMA system uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users. The separation of the signals is made by correlating the received signal with the locally generated code of the desired user. If the signal matches the desired user's code then the correlation function will be high and the system can extract that signal. If the desired user's code has nothing in common with the signal the correlation should be as close to zero as possible (thus eliminating the signal).

4. CORRELATION SCORE

The last N quantized samples $q[1]$, $q[2]$, ..., $q[N]$ are memorized, with $q[N]$, the oldest sample. The value of N is chosen to be dividable by 3, such that there are an integer number of samples per chip.

The references are fixed values defined in Table 1. They can be noted as $r_j[i]$, with j the reference number and i the sample number. For example, $r_2[1]=2$. This is reference 2, newest sample, therefore, the third chip value: 2.

The boundary crossing between symbols and chips are subject to inter-symbol interference. Therefore, their values are considered as unknown. In order to take this into account, the inter-chip reference values are not compared. This is accounted by the $c[i]$ variable, as described in (1).

$$c[i] = \begin{cases} 0 & \text{if } i=1, \frac{N}{3}, \frac{N}{3} + 1, \frac{2N}{3}, \frac{2N}{3} + 1, N \\ 1 & \text{other } i \text{ values} \end{cases} \quad (1)$$

The sample correlation score, $\sigma_j[i]$, for reference j and sample i can then be defined in (2).

$$\sigma_j[i] = \begin{cases} -|q[i] - r_j[i]| & \text{if } q[i] \neq r_j[i] \\ 1 & \text{if } q[i] = r_j[i] \end{cases} \quad (2)$$

Equation (2) can be explained as follow: the sample is compared to an expected reference value. If they are equal, the score is incremented; if they are different the score is decreased. In the case that the difference between the reference and the sample is 1, the score is decremented. In the case that the difference between the reference and the sample is 2, the score is decreased by 2. This rejects stronger a big difference between the expected signal and the received one. It