Miller Decoding Algorithm Using Sample Recovery and Correlation Method for UHF Gen2 RFID System

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Abstract: In this paper, by analyzing the characteristics of the received signal in both practical and theory environment, a Miller decoding algorithm basing on a sample recovery method and correlation concept is designed. The sample recovery method is designed to apply on the samples of the received signal which often include some degree of distortions caused by noise or timing jitter. Basing on the concept of matched filter, which is obtained by correlating the received signal with a known reference signal to detect the presence of the data symbol in the received signal, a Miller decoding algorithm utilizing correlation is designed. Together with the signal recovery method, the Miller decoding algorithm using correlation shows a good decoding performance under condition of timing jitter and high signal corruption rate caused by noise.

1. Introduction

Radio frequency identification (RFID) technology is a wireless telecommunication technology that the data signal is transmitted between system elements through radio channels. UHF RFID system can be generally divided into two parts -reader and tag which communicate with each other through the air interface. FM0 and Miller modulation/encoding mode is recommended by Gen2 RFID standard for high data rates. The FM0 encoding mode is often used for the baseband single reader environment, while the Miller encoding mode (Figure 1) is specially used in dense-reader environment.

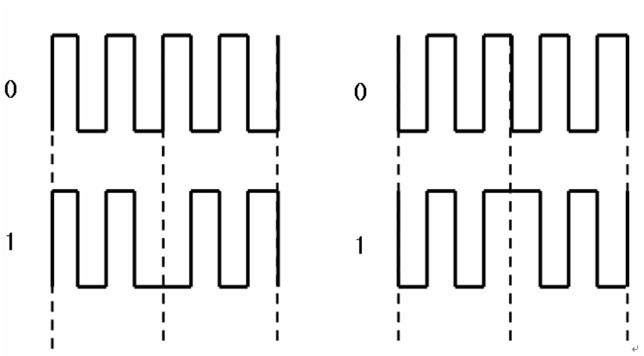

Figure 1 Miller symbols defined in Gen2 RFID (M=4)

In FM0 mode the tag signal has a single sub-carrier signal and conventionally the FM0 signals are processed using an algorithm as incoherent algorithm basing on correlating the received signal with two reference signals. While in Miller mode, there are numerous sub-carriers in the tag signal comparing with the FM0 mode which bring more difficulties for signal proceeding. A disadvantage of the conventional incoherent algorithm used in FM0 mode is

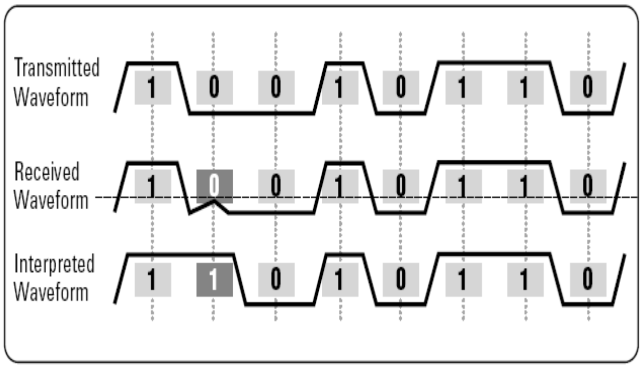

Figure 2 Jitter can cause receiver to misinterpret transmitted [1]

that the references signal doe not have a zero mean, and therefore correlation of received signal does not remove constant DC component. In a typical RFID environment, the conventional incoherent algorithm can only achieve desired performance with a comparatively high signal-to-noise ratio (SNR) when the communication distance becomes relatively large. So, new high-speed RFID systems need more efficient techniques for demodulation and decoding of backscatter signals in readers.

The desired techniques are like providing simplified hardware implementation with minimum computations. For the requirement of high-speed effective decoding of back-scatter signals in readers, an improved decoding technique is desired to provide simply hardware implementation and minimum computations. The present method in this paper provides stable performance and reliable decision making. Also, the method provides both reliable data decoding and simple implementation of the base-band reader receiver.

2. Evaluation Method

In UHF Gen2 RFID system, the tags shall encode the data as either FM0 symbols or Miller symbols. The FM0 encoding format is often used for the baseband single reader environment, while the Miller encoding format is specially used in dense-reader environment. When using Miller encoding format, since there are numerous sub-carrier cycles per bit comparing with the FM0 code format, so it is ineffective to use conventional FM0 decoding algorithm on Miller decoding. In the decoding process, the timing jittering phenomenon has a serious degrading affect to the sampling and decoding performance. So a signal recovery method is designed to apply on the received data to correct the sampled signals distorted by timing jitter phenomenon.

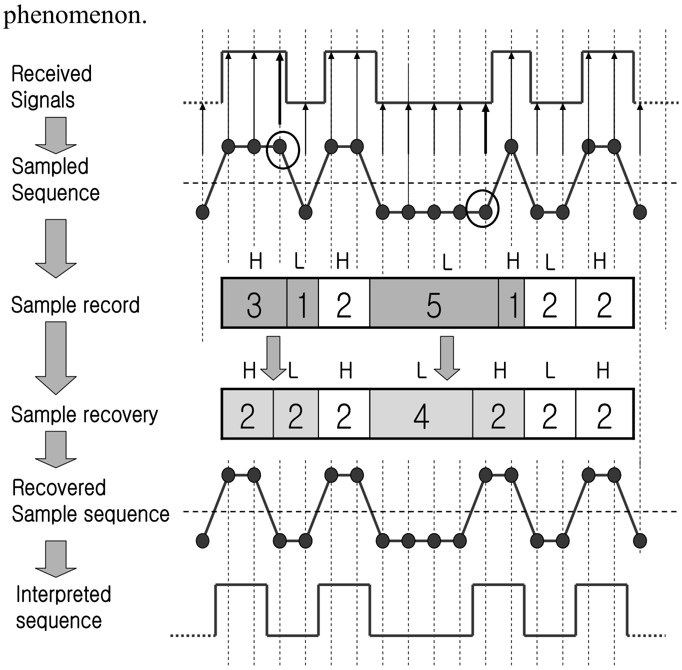

Figure 3 Miller decoding algorithm architecture

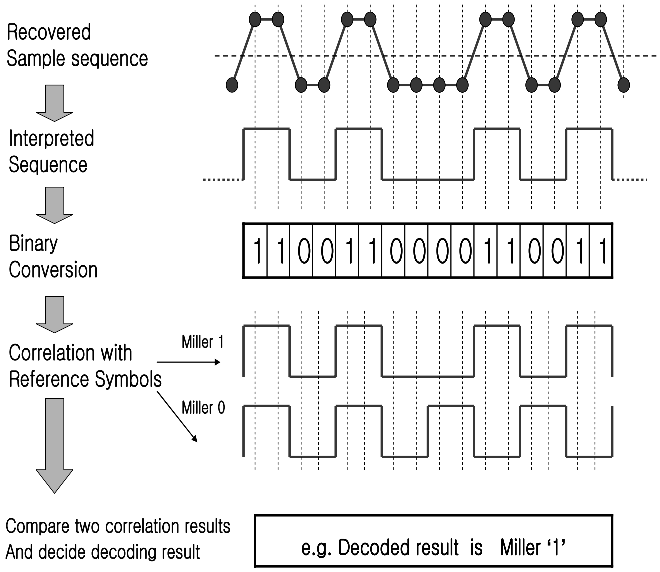

Figure 4 Miller decoding algorithm architecture (continue)

So in order to overcome the sampling problem caused by Jitter[2], and for better decoding performance making use of correlation idea[4]. The sample recovery method is made to correct the problem existing samples caused by Jitter[3]. Then basing on the correct sample sequence , the correlation can be performed to decode the Miller sequence. The Miller decoding algorithm architecture is illustrated above in Figure 3 and 4.

In this situation shown by the Figure 3 and 4 above , the Miller sequence is sampled by a 4 times sampling frequency of the carrier frequency: Fs= 4* Fc (Fs=800kHz, Fc=200kHz, data rate =50kbps) . It can be seen that there exist some sample distortions in the received signals.

As shown in the Figure 3, on receiving the signals, by detecting the transition occurrence in the received sample sequence, the number of continuous samples having same status (High or Low) can be stored, like the number of continuous sample with High (H) status or Low (L) status . Then comparing with the ideal sampled sequence, the incorrect sample length is corrected. Shown in Figure 3 above, the wrong number of high status samples caused by jitter phenomenon which caused the not proper sampling position is corrected to the ideal case Then basing on the corrected samples, the sample sequence can be interpreted correctly, instead of the problem existing interpreted sequence.

After performing the sample recovery method, the corrected sample sequence is prepared to be decoded utilizing correlation. The decoding process is illustrated in the Figure 4.For the sake of performing correlation, the interpreted sequence is converted to a sequence consisting of binary values as 0 and 1 basing on the high or low status and the position of the samples. Then by performing the correlation with the reference Miller symbol 0 and Miller symbol 1[5], separately, the correlation results are compared to find out the more relativeness between the Miller 0 and Miller 1. The bigger correlation value indicates a more similarity to that reference Miller symbol. So basing on this idea, the decoding result can be decided.Basing on the concept of correlation defined in the probability theory, the calculation of correlation used in the decoding process is not using the strict definition of the correlation defined in the probability theory. For the sake of minimizing the calculation load in practical implementation, the calculation of our defined correlation is defined as the Figure 5 below.

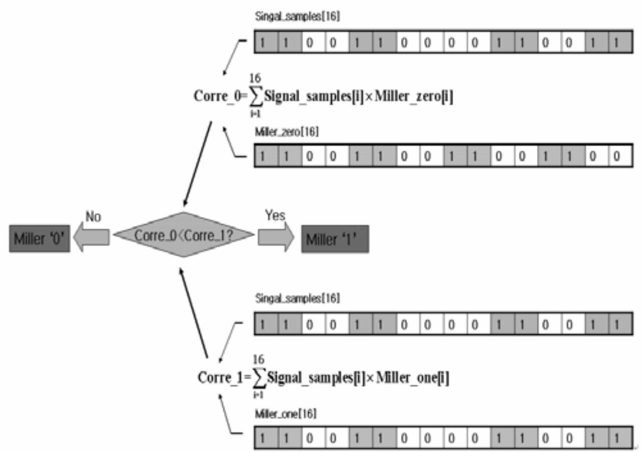

Figure 5 Calculation of correlation with reference Miller 0 and 1 symbol

The flowchart of the entire Miller decoding algorithm is shown in Figure 5. On start sampling the received signal from tag, the digital sample values directly received from ADC are saved in the buffer of the CPU memory. Then by detecting the transition happenings in the received sample sequence, the continuous high and low status of the sample sequence is recorded and saved in the second buffer. Then the sample recovery method is performed on the second buffer to recover the distorted samples to ideal status and the recovered sample sequence is saved in the third buffer. Up to here, the processing of the sample sequence is finished and the sample sequence is ready for performing the decoding. By binary conversion, the sample sequence will be converted to a sequence consisting 0 and 1, depending on the sample position and length. Then the binary sequence is correlated with the reference Miller symbol 0 and 1, respectively.

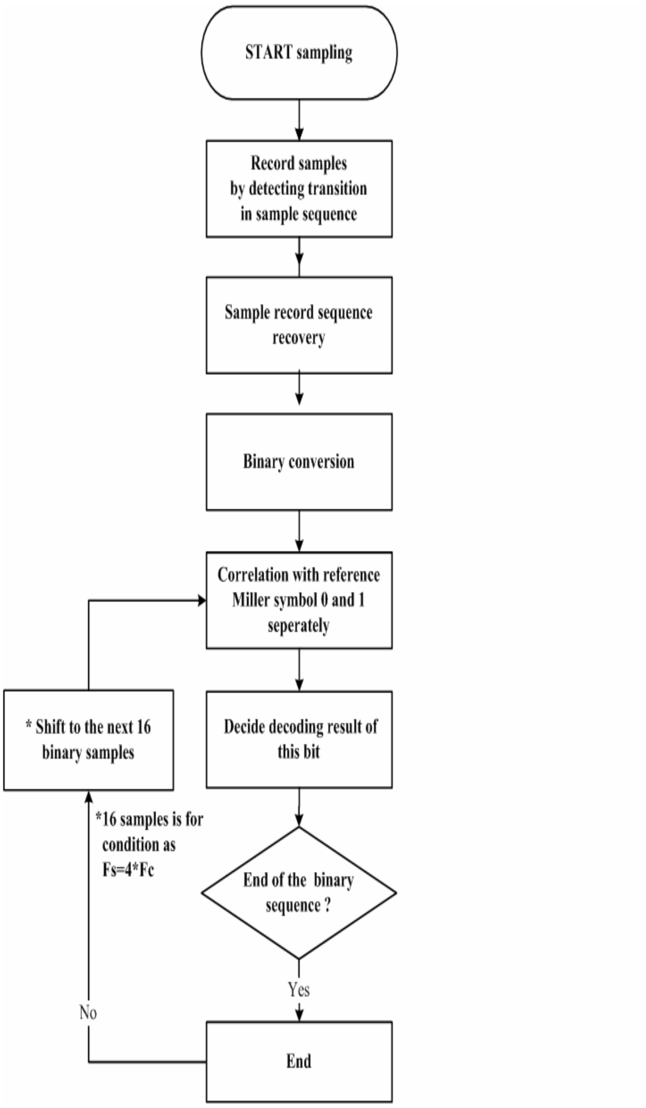

Figure 6 Overall Miller decoding algorithm flow-chart

By comparing the correlation results, the decoding result of this bit can be decided. By shifting to the next 16 binary samples in the binary sample sequence, the correlation calculation and decision making procedure will be repeated until the end of the binary sample sequence.

3. Experimental Data

In this paper, by analyzing the characteristics of the received signal in both practical and theory environment, a Miller decoding algorithm basing on a sample recovery method and correlation concept is designed. The sample recovery method is designed to apply on the samples of the received signal which often include some degree of distortions caused by noise or timing jitter. In condition of 4 times sampling rate that is the sampling frequency is 4 times of the original signal carrier frequency (Fs=4*Fc), the sampling recovery method could achieve a successful recovering rate as 75%. The successful recovering rate increases as we increase the sampling rate. In case of 6 times sampling rate (Fs=6*Fc) it could achieve a successful recovery rate as 100%. However, a higher sampling rate also results in heavier calculation load and higher requirement for hardware calculation speed. So a minimum of 4 times sampling rate (Fs=4*Fc) is proposed for effectively using the sample recovery method.

4. Evaluation Result

The designed Miller decoding algorithm using sample recovery method and correlation was implemented on the TMS320C5502 DSP platform. The Miller format response signal is received from the Alien EPC Gen2 tag, and sampled by the ADC (AD9059). The implementation result is captured in CCS environment.

From the Figure 7 below, the upper part is the original sample sequence received from ADC. It can be seen that the sample sequence has numerous distorted parts caused by noise or timing jitter. The sequence in this status is difficult to be effectively decoded. The lower part of the figure is the recovered sample sequence using the designed sample recovery method. By comparing the same part of the sequence, it can be seen that the recovered sample sequence achieves very good status for decoding since the recovered sequence obeys the Miller code format strictly.

By using CRC checking method [5] for error checking, we can check whether the decoding result is right or wrong. In the measurement using the designed Miller decoding algorithm, it has achieved a successful decoding rate from 10 times per second to 100 times per second according to different tags.

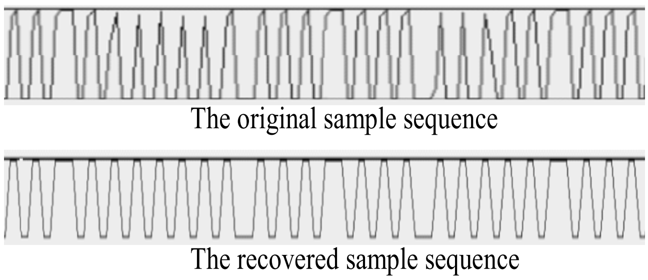

Figure 7 Experimental sample sequence recovery result (Implemented on TMS320C 5502 DSP platform)

5. Acknowledgement

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