IEEE 802.11
Wireless Access Methods and Physical Layer Specifications

TITLE: Scrambling, DC Bias and Run Length Control and Making CCA Easy

DATE: July 11-14th,1994

AUTHOR: Ed Geiger
Apple Computer
One Infinite Loop
Cupertino, CA 95014
edg@apple.com

Kerry Lynn
Apple Computer
One Infinite Loop
Cupertino, CA 95014

Frank Hayden
GEC Plessey Semiconductors
1500 Green Hills Road
P. O. Box 660017
Scotts Valley, Ca 95067-0017

Introduction

This paper looks at using a data encoding technique to resolve several problems the PHY group has been dealing with over the last several meetings. These problems include scrambling, controlling the DC bias or offset, and limiting the run length of ones or zeros. In addition to solving these problems, this coding technique then reduces some of the issues involved with clear channel assessment.

1.0 Introduction

Over the pass several meetings, the PHY working group has been trying to find solutions to the following problems:

- Limiting DC Bias
    - Bit Stuffing cost 6% 16B/17B
      cost 3% 32B/33B

- Minimizing Run Length
    - No leading Method

- Scrambling
    - Frame synchronous scrambler Results are unknown

1.1 Limiting DC Bias. The current proposal is to do fixed length bit stuffing where a bit is added to every sixteen bits to indicate whether the 17 bit block is encoded normally or inverted. Simulation has shown that this method will balance out over the long run the number of ones and zeros present in any transmission. This parameter is important to radio designers when considering the design for both the transmitter and receiver data loops. The current proposal can help to limit the run length of ones or zeros to about 48 bits.

1.2 Minimizing Run Lengths. Controlling the number of ones or zeros that can appear together in the transmitted data stream is useful from two perspectives. One is that by limiting the run length, one can help to reduce the period of time it takes to average the DC bias. This significantly reduces the complexity of the transmit and receive data loops. The second perspective concerns clear channel assessment.

One of the probable tests of the clear channel assessment state machine will be to determine if a detected carrier contains data from a similar 802.11 PMD or if the carrier energy is from an interfering source. Determining the difference between 802.11 data and some other noise source requires lots of transitions for comparisons. If the 802.11 data run lengths are long, the time to determine clear channel assessment will also be long and the sophistication of the CCA circuitry will be high. Short run lengths equate to short CCA times and lower CCA design complexity.

1.3 Scrambling. One method which some networks use to break up certain sensitive transmissions patterns is scrambling. Scrambling can effectively be used to break up longs runs of ones or zeros but then there are patterns of random data which will match the scrambling pattern and create other long runs of ones or zeros. This means some data patterns may not always produce the same CCA results. The odds of these patterns appearing versus ones and zeros is certainly a subject of debate (1).

2.0 Data Encoding

One technique for controlling DC Bias, fixing run lengths, avoiding scrambling and bit stuffing, and reducing the timing and complexity of CCA is to do data encoding. One method is to encode the NRZ data stream using Delay Modulation or Miller coding. (2)

2.1 What is Delay Modulation. Delay Modulation was developed to squeeze more data onto mag tapes in the mid 70's. Other coding techniques have evolved from this initial discovery such as Miller Squared and IBM's 2:7 coding. We have been looking at this for some time and are impressed with the initial investigation into this technique.

The delay-modulation code is basically a phase shifted code and can be defined as follows: A ONE is represented always by a transition in the middle of a bit cell. A ZERO has no transition, unless it is followed by another zero, in which case there is a transition at the end of the first Zero's bit cell. This format is arbitrary and the definitions of a data ONE or ZERO can be interchanged.

Figure 1 shows an example of how various NRZ signals get encoded using delay modulation.

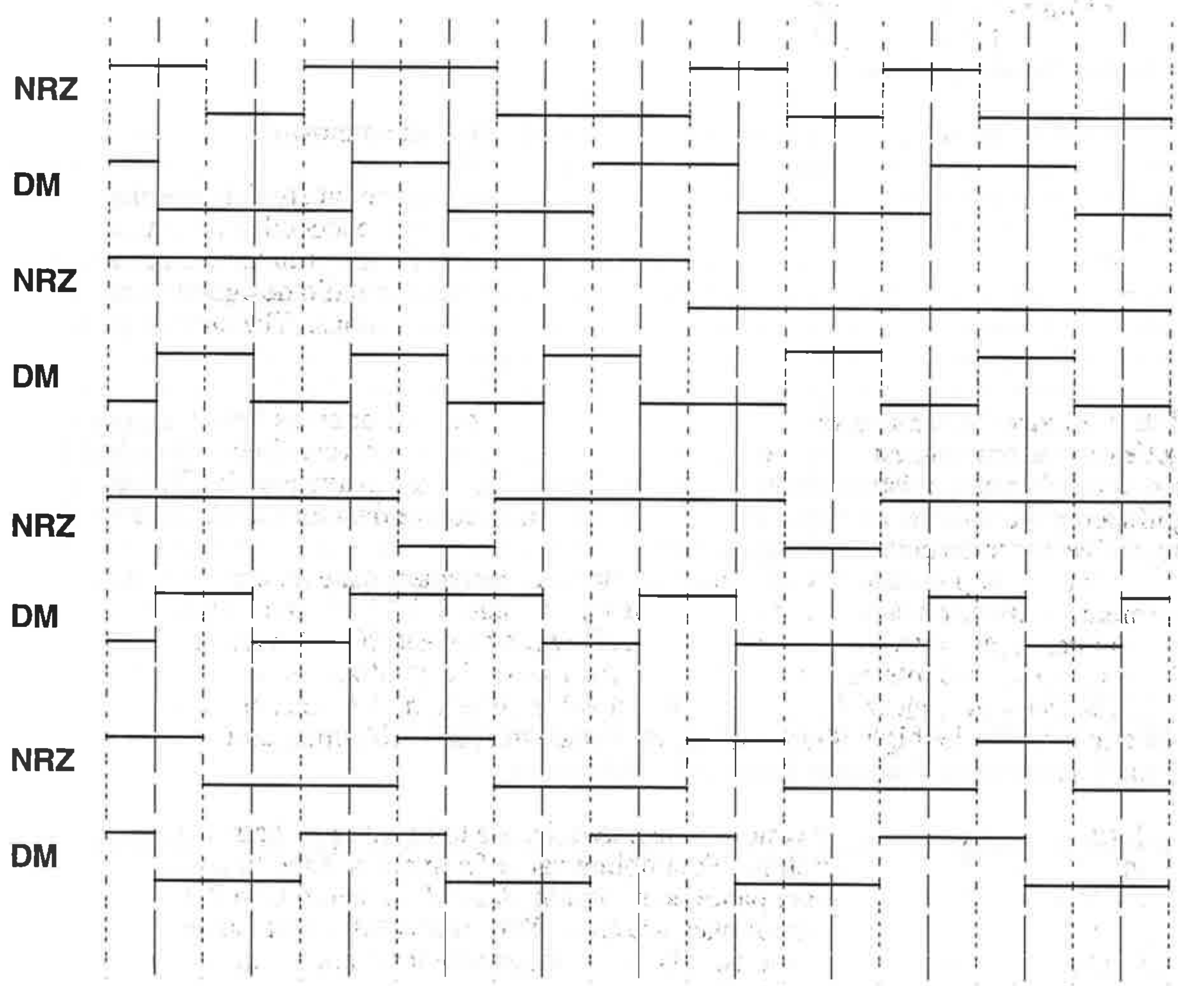


Figure 1
NRZ versus Delay Modulation Encoding

2.2 Coding Gains. In addition to controlling run lengths and insuring transitions, another feature of Delay Modulation is that its coding scheme provides some gains when dealing with errors and distinguishing between noise and data. When errors occur in NRZ, there is little help in the NRZ encoding technique to help identify and restore erred bits. In delay modulation, some errors which cause coding violations can be used to restore the original data. But in turn, some errors might also allow the decode mechanism to error two bits rather than one.

Coding also helps distinguish quickly between noise and data. NRZ has many patterns of either lots of transitions or no transitions. This allows some forms of noise or interference to be much harder to distinguish from data. DM only allows very specific patterns in short periods of time thus reducing the probability of random noise appearing as data.

3.0 Radio Considerations

Long strings of ones and zeros in a data stream can cause drift problems in phase locked loops. This has the effect of corrupting the received data. With delay modulation the run length is limited to a maximum of two bits. This then overcomes the problem of drift in the phase locked loop when using NRZ type data.

When the run length is limited to a maximum of two bits, the average voltage into the modulation loop is less. This means that the frequency deviation for a DM coded bit stream will be less than it would be with NRZ data. The deviation could then be increased effectively increasing the amount of signal, so that some gain in signal to noise ratio is incurred.

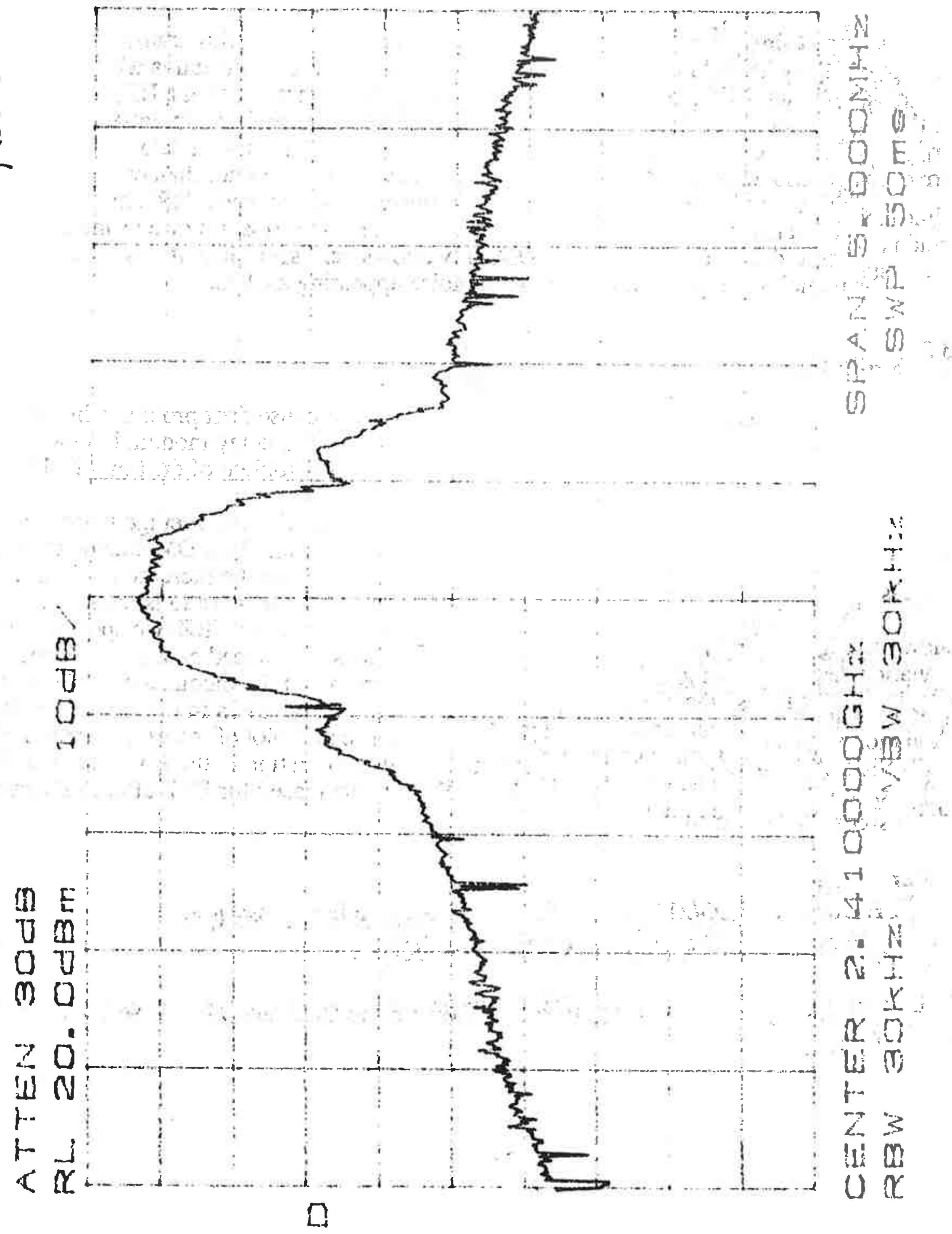
As an example of the spectral characteristics of DM versus NRZ two spectral plots are shown in Figure 3 and Figure 2. Both plots are for a Gaussian shaped data prefilter with the deviation setting unchanged. The modulator was set up so that the modulated carrier met FCC part 15 requirements when modulated with NRZ data. This is shown in Figure 2. With the deviation set the same as for NRZ, Figure 2 shows a spectral plot of the same carrier modulated with NRZ. As can be seen from Figure 3, the amount of deviation in the DM case is less than the NRZ spectrum. This means that the deviation could be increased for DM, effectively putting more signal in the transmitter.

References

1. IEEE Doc 802.11-93/216, " A Look at Some Scrambling Techniques Used in Various Data Transport Protocols", Ed Geiger.

2. Electronic Design 21, Oct. 11, 1975, " Squeeze more Data onto Mag Tape", Walter E. Bently and Spyros G. Varsos.

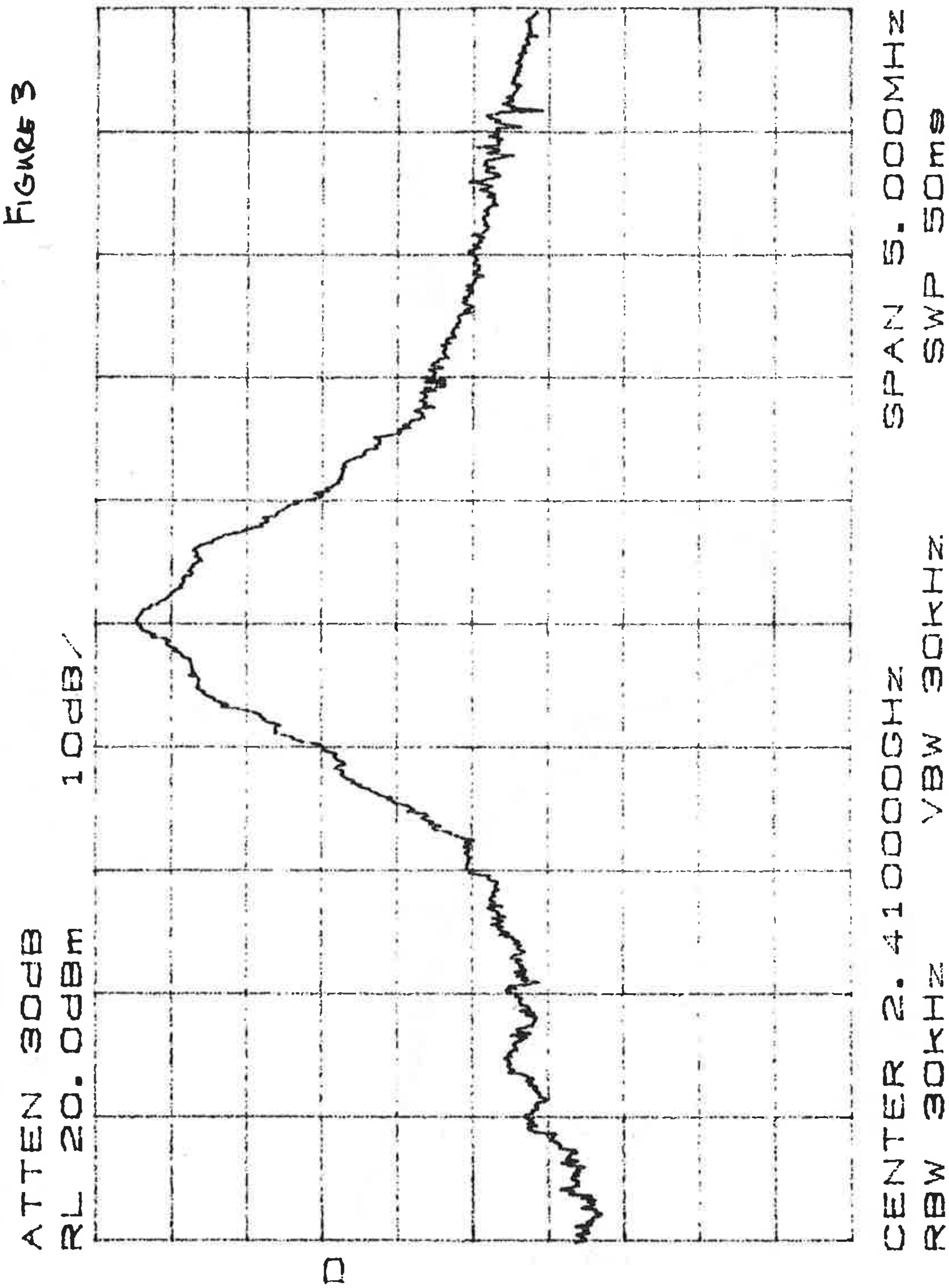
94/201
Figure 2



(6)

94/201

FIGURE 3



(7)