Partitioned DC-Balanced (0,6) 16B/18B Transmission Code

*Albert X. Widmer*

IBM T. J. Watson Research Center  
Route 134  
Yorktown Heights, New York 10598-0218

Phone: 1-914-945-2047  
e-mail: widmer@us.ibm.com
Purpose and Goals

- **Increase coding efficiency** from 80% to 89% as an alternative to scrambling
- Maintain essential features of 8B/10B code:
  - Compact singular *Comma*
  - A few other non-data *control* characters
  - DC-Balance and decent *low frequency* characteristics
  - Partitioned structure for simpler implementation
  - Error Detection
  - Suitable for *Error Correction* feature
Basic Structure

• 16B/18B code is *partitioned* into a 9B/10B code and a 7B/8B code
• Both codes use sets of balanced vectors, and complementary vectors with disparity of $\pm 2$ and $\pm 4$
• The Running disparity at the 18B, 10B, and 8B boundaries is limited to $\pm 1$ and $\pm 3$
• The singular non-data 2 byte *comma* sequence:
  • For a *negative* starting disparity, it is ‘001111110’1110xxxx’ where the 4-bit set xxxx can be any single one combined with 3 zeros
  • The comma search can be limited to the 10 bold underlined ones
  • For a *positive* starting disparity, the entire above sequence is complemented.
Transmission Parameters

• Maximum **Run length is 7**, no contiguous runs of 7

• **Low Frequency** Characteristics
  • Maximum Digital Sum Variation is **12**
  • Normalized offset is \(87:18 = 4.83\) (1.9 for FC code)
  • The low frequency time constants in circuits have to be increased by a *factor of 2.25* *compared with Fibre Channel code*

• Non-data **Control** Characters
  • 10B domain: **5**
  • 8B domain: 0

* Analysis by Dr. J.F. Ewen, IBM Rochester
16B/18B Trellis Envelope, Comma

- **Comma**: $7 + 3 = 10$ bits to check versus 6 for FC code
- Comma extends over 2 bytes
- 4 different 2-byte comma sequences available
Implementation

- Implementation approaches similar to FC code are preferred, perhaps supplemented by small tables for some translations which are not readily obtained by parity-type circuits

- The number of required gates for encoding and decoding is higher than for Fibre Channel code

- The disparity control is more complex than for FC code

- FC coding, framing and decoding can comfortably be done at 4-byte intervals using 0.16 micron lithography CMOS technology. It is more difficult to fit 16B/18B coding and decoding into the same timing structure.
Encoder and Decoder Diagrams

16B/18B Encoder

DataIn <0:15>

Control (K)

Disparity Control

Complement 8B

Running End Disparity (+3,+1,—1,—3)

Running Front Disparity (+3,+1,—1,—3)

9B/10B Encoder

7B/8B Encoder

8B Block Disparity (0,+2,+4)

10B Block Disparity (0,+2,+4)

Complement 10B

Coded_Data <0:17>

18B/16B Decoder

Coded_Data <0:17>

Control (K)

Invalid 10B

Invalid 8B

Disparity Violation in 10B

Disparity Violation in 8B

Running End Disparity (+3,+1,—1,—3)

Running Front Disparity (+3,+1,—1,—3)
Error Correction with 16B/18B Code

- The Error Correction technique developed for the FC code works also with the 16B/18B code if minor modifications are made
  - The 10B and 8B fields are treated as identical, individual blocks
  - The *B-Balanced bits* are redefined to have a value of one if the respective 10B or 8B vector has a *disparity of 0 or ±4*, and a zero value for a disparity of ±2
  - Because of the lesser precision of error locating, the *search range* is extended. It is assumed that an error occurred in the 64-byte range ending with the byte where a disparity error is detected (versus a 16-byte range). This extension requires 4 more parity bits
  - The total number of required parity bits is 21: 9 for vertical parity and 12 for locating the erroneous byte
Conclusion

- A 16B/18B code can be developed to gain better *coding efficiency*
- The most important features of the FC code are preserved
- The implementation is more complex than the FC code but probably less than a total solution using scrambling