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**Information technology — International  
symbology specification — Data matrix**

*Technologies de l'information — Spécification internationale des  
symboles — Matrice de données*

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## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 16022 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

International Standard ISO/IEC 16022 was prepared by AIM International (as ANSI/AIM BC11) and was adopted, under a special "fast-track procedure", by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

Annexes A to P form a normative part of this International Standard. Annexes Q to V are for information only.



# Information technology — International symbology specification — Data matrix

## Introduction

Data Matrix is a two-dimensional matrix symbology which is made up of square modules arranged within a perimeter finder pattern. Though primarily shown and described in this document as a dark symbol on light background, Data Matrix symbols can also be printed to appear as light on dark.

Manufacturers of bar code equipment and users of the technology require publicly available standard symbology specifications to which they can refer when developing equipment and application standards. The publication of Symbology Specifications is designed to achieve this.

## 1 Scope

This specification defines the requirements for the symbology known as Data Matrix. It specifies the Data Matrix symbology characteristics, data character encodation, symbol formats, dimensions and print quality requirements, error correction rules, decoding algorithm, and user-selectable application parameters.

## 2 Normative References

This specification incorporates provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed below. The latest edition of the publication referred to applies.

EN796 Bar Coding : Symbology Identifiers

EN1556 Bar Coding : Terminology

ANSI  
X3.182 Bar Code Print Quality - Guideline  
(Same as EN1635 - Bar Coding :  
Test Specifications for Bar Code  
Symbols)

ANSI  
X3.4 Coded Character Sets - 7-bit  
American National Standard Code  
for Information Interchange (7-bit  
ASCII)  
(equivalent to the US national  
version of ISO 646)

ISO/IEC  
8859-1 Information Processing - 8-bit  
Single-byte Coded Graphic  
Character Sets - Part 1 (Latin  
Alphabet Number 1)

ECI Assignments Document- AIM International

## 3 Definitions and Mathematical Symbols

### 3.1 Definitions

For the purposes of this specification, the following definitions in EN 1556 shall apply:

algorithm, application standard, ASCII, autodiscrimination, binary, bit, CCD, code page, code set, data character, data codeword, data region, data separator character, decode algorithm, decoder, error correction, finder pattern, human readable character, latch character, leading zeros, matrix symbology, modulo, numeric, omnidirectional, orientation pattern, overhead, pad character, pixel, quiet zone, reference decode algorithm, Reed-Solomon error correction, scanner, shift characters, structured append, symbol character, symbology, symbology identifier, X-dimension

The following definitions also apply to this specification. Although some of the terms below are defined in EN1556, the definitions which follow below are more appropriate for this specification.

#### 3.1.1 Alignment Pattern

A unique pattern in larger ECC 200 Data Matrix symbols, made up of a solid line of contiguous dark cells abutting a line of alternating dark and light cells. The alignment patterns run horizontally and vertically within the symbols.

#### 3.1.2 Codeword

A symbol character value. An intermediate level of coding between source data and the graphical encodation in the symbol.

### 3.1.3 Module

A single cell in a matrix symbology used to encode one bit of data. In Data Matrix the module is a square shape.

### 3.1.4 Convolutional Coding

An Error Checking and Correcting (ECC) algorithm that processes a set of input bits into a set of output bits that can recover from damage. The encoding process consists of breaking the input bits into blocks, then convolving each input block with the contents of a multi-stage shift register to produce protected output blocks. These encoders can be constructed in hardware using input and output switches, shift registers, and exclusive-or (XOR) gates.

### 3.1.5 Cyclic Redundancy Check (CRC)

An error detection algorithm which performs binary modulo 2 long division of a binary input stream by a fixed binary bit stream and produces as output the remainder of this division. The fixed binary bit stream is usually represented by a polynomial. The remainder of the division is the CRC value. The division can be implemented in hardware by shift registers and XOR gates. The purpose of a CRC is to provide error detection allowing validation of the user data after correction by the ECC process.

### 3.1.6 Extended Channel Interpretation (ECI)

A protocol used by some symbologies that allows the output data stream to have interpretations other than that of the default character set.

### 3.1.7 Pattern Randomizing

A procedure which converts an original bit pattern to another bit pattern by inverting selected bits. The resulting bit stream is less likely to have repeating patterns.

## 3.2 Mathematical Symbols and Operation

For the purposes of this specification, the mathematical symbols which follow shall apply globally unless defined locally:

- d number of error correction codewords
- e number of erasures
- k (for ECC 000 - 140) the number of bits in a complete segment input to the state machine to

generate the convolutional code

(for ECC 200) total number of error correction codewords

m the memory order of the convolutional code

n (for ECC 000 - 140) the number of bits in a complete segment generated by the state machine producing the convolutional code (for ECC 200) total number of data codewords

N the numerical base in an encoding scheme

p number of misdecode protection codewords

S symbol character

t number of errors

u the input bit segment to the state machine, taken k bits at a time

v the output bit segment from the state machine, generated n bits at a time

X horizontal and vertical width of a module

ε error correction codeword

For the purposes of this specification, the notations and mathematical operations which follow shall apply:

- div is the integer division operator
- mod is the integer remainder after division
- XOR is the exclusive-or logic function whose output is one only when its two inputs are not equivalent.
- LSB Least significant bit
- MSB Most significant bit

## 4 Symbol Description

### 4.1 Basic Characteristics

Data Matrix is a two-dimensional matrix symbology. There are two types: ECC 000 - 140 with several available levels of convolutional error correction and ECC 200 which uses Reed-Solomon error correction. For new applications ECC 200 is recommended. ECC 000 - 140 should only be used in closed applications where a single party controls both the production and reading of the symbols and is responsible for overall system performance. The characteristics of Data Matrix are:

a. Encodable character set:

1. values 0 - 127 in accordance with ANSI X3.4, i.e. all 128 ASCII characters

(equivalent to the U.S. national version of ISO 646)

2. values 128 - 255 in accordance with ISO 8859-1; Latin Alphabet No. 1. These are referred to as extended ASCII
- b. Representation of data: A dark module is a binary one and a light module is a zero.
- c. Symbol size in modules (not including quiet zone):
 

|                      |                |
|----------------------|----------------|
| <u>ECC 000 - 140</u> | <u>ECC 200</u> |
| 9 by 9               | 10 by 10       |
| to 49 by 49          | to 144 by 144  |
| Odd Only             | Even Only      |
- d. Data characters per symbol (for maximum symbol size in ECC200):
 

|                       |                       |
|-----------------------|-----------------------|
| 1. Alphanumeric data: | up to 2335 characters |
| 2. 8-bit byte data:   | 1556 characters       |
| 3. Numeric data:      | 3116 digits           |
- e. Selectable error correction:
 

|                |                                                                                              |
|----------------|----------------------------------------------------------------------------------------------|
| ECC 000 - 140: | Four levels of convolutional error correction, plus the option to apply only error detection |
| ECC 200:       | Reed-Solomon error correction                                                                |
- f. Code type: Matrix
- g. Orientation independence: Yes

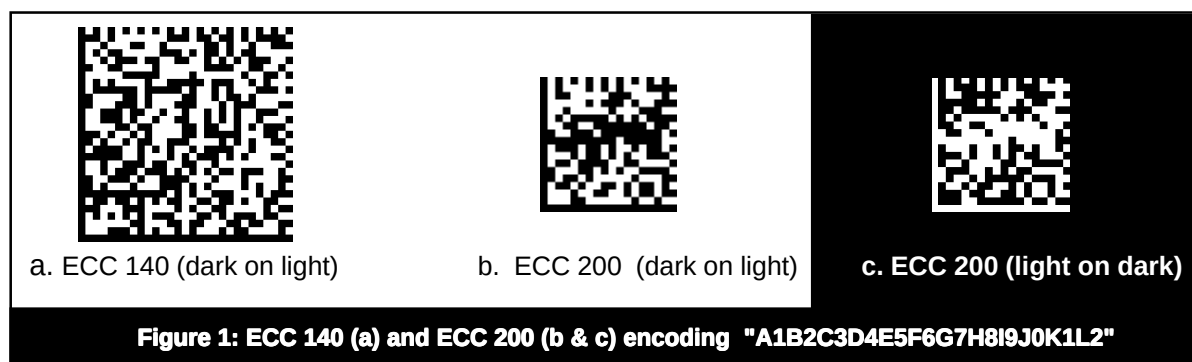
#### 4.2 Summary of Additional Features

The following summarises additional features which are inherent or optional in Data Matrix:

- a. Reflectance reversal: (Inherent) Symbols are intended to be read when marked so that the image is either dark on light or light on dark (see Figure 1).
- b. Extended Channel Interpretations: (ECC 200 only, optional) This mechanism enables characters from other character sets (e.g. Arabic, Cyrillic, Greek, Hebrew) and other data interpretations or industry-specific requirements to be represented.
- c. Rectangular symbols: (ECC 200 only, optional) Six symbol formats are specified in a rectangular form.
- d. Structured append: (ECC 200 only, optional) This allows files of data to be represented in up to 16 Data Matrix symbols. The original data can be correctly reconstructed regardless of the order in which the symbols are scanned.

#### 4.3 Symbol Structure

Each Data Matrix symbol consists of data regions which contain nominally square modules set out in a regular array. In larger ECC 200 symbols, data regions are separated by alignment patterns. The data region is surrounded by a finder pattern, and this shall be surrounded on all four sides by a quiet zone border. Figure 1 illustrates an ECC 140 and two representations of an ECC 200 symbol.



#### 4.3.1 Finder Pattern

The finder pattern is a perimeter to the data region and is one module wide. Two adjacent sides, the left and lower sides, forming the L boundary, are solid dark lines; these are used primarily to determine physical size, orientation and symbol distortion. The two opposite sides are made up of alternating dark and light modules. These are used primarily to define the cell structure of the symbol, but also can assist in determining physical size and distortion.

#### 4.3.2 Symbol Sizes and Capacities

ECC 000 - 140 symbols have an odd number of rows and an odd number of columns. Symbols are square with sizes from 9 x 9 to 49 x 49 (modules) not including quiet zones. These symbols can be recognized by the upper right corner module being dark. The complete attributes of ECC 000 - 140 symbols are given in Annexe A.

ECC 200 symbols have an even number of rows and an even number of columns. Some symbols are square with sizes from 10 x 10 to 144 x 144 not including quiet zone. Some symbols are rectangular with sizes from 8 x 18 to 16 x 48 not including quiet zone. All ECC 200 symbols can be recognized by the upper right corner module being light. The complete attributes of ECC 200 symbols are given in Table 11 in Section 6.5.

## 5 ECC 000 - 140 Requirements

For new applications or open systems ECC 200 is recommended (See Section 6).

### 5.1 Encode Procedure Overview

This section provides an overview of the encoding procedure. Following sections will provide more details. An example encode for ECC 050 is given in

Annexe Q. The following steps convert user data to an ECC 000 - 140 symbol:

#### Step 1: Data Encodation

The user data is analyzed to identify the variety of different characters to be encoded. For maximum compaction efficiency, the lowest level encodation scheme capable of encoding the data should be selected. If the user does not specify the matrix size, then choose the smallest size that accommodates the data. The result of this step is called the Encoded Data Bit Stream.

#### Step 2: Data Prefix Construction

A Data Prefix Bit Stream is constructed from the Format ID, CRC, and Data Length bit fields. This Data Prefix Bit Stream is prefixed to the Encoded Data Bit Stream to produce the Unprotected Bit Stream.

#### Step 3: Error Checking and Correcting

The Unprotected Bit Stream is processed by the user specified convolutional coding encode algorithm to produce the Protected Bit Stream. This step is omitted for ECC 000.

#### Step 4: Header and Trailer Construction

A header containing only the ECC bit field is prefixed to the Protected Bit Stream. A trailer containing pad bits (zeros) is appended to the Protected Bit Stream. The Protected Bit Stream with the header and trailer added is called the Unrandomized Bit Stream.

#### Step 5: Pattern Randomizing

The Unrandomized Bit Stream is processed by the pattern randomizing algorithm and produces the Randomized Bit Stream.

| Encodation Scheme | Characters                              | Bits per Data Character |
|-------------------|-----------------------------------------|-------------------------|
| Base 11           | Numeric data                            | 3.5                     |
| Base 27           | Upper-case alphabetic                   | 4.8                     |
| Base 37           | Upper-case alphanumeric                 | 5.25                    |
| Base 41           | Upper-case alphanumeric and punctuation | 5.5                     |
| ASCII             | Full 128 ASCII set                      | 7                       |
| 8-bit Byte        | User defined                            | 8                       |

**Table 1: Encodation Schemes**

**Step 6: Module Placement in Matrix**

Modules are placed in a matrix to construct the finder pattern. The Randomized Bit Stream is placed into the matrix one module at a time according to the data module placement algorithm given in Annexe B.

Figure 2 shows the various bit streams during the encode process.

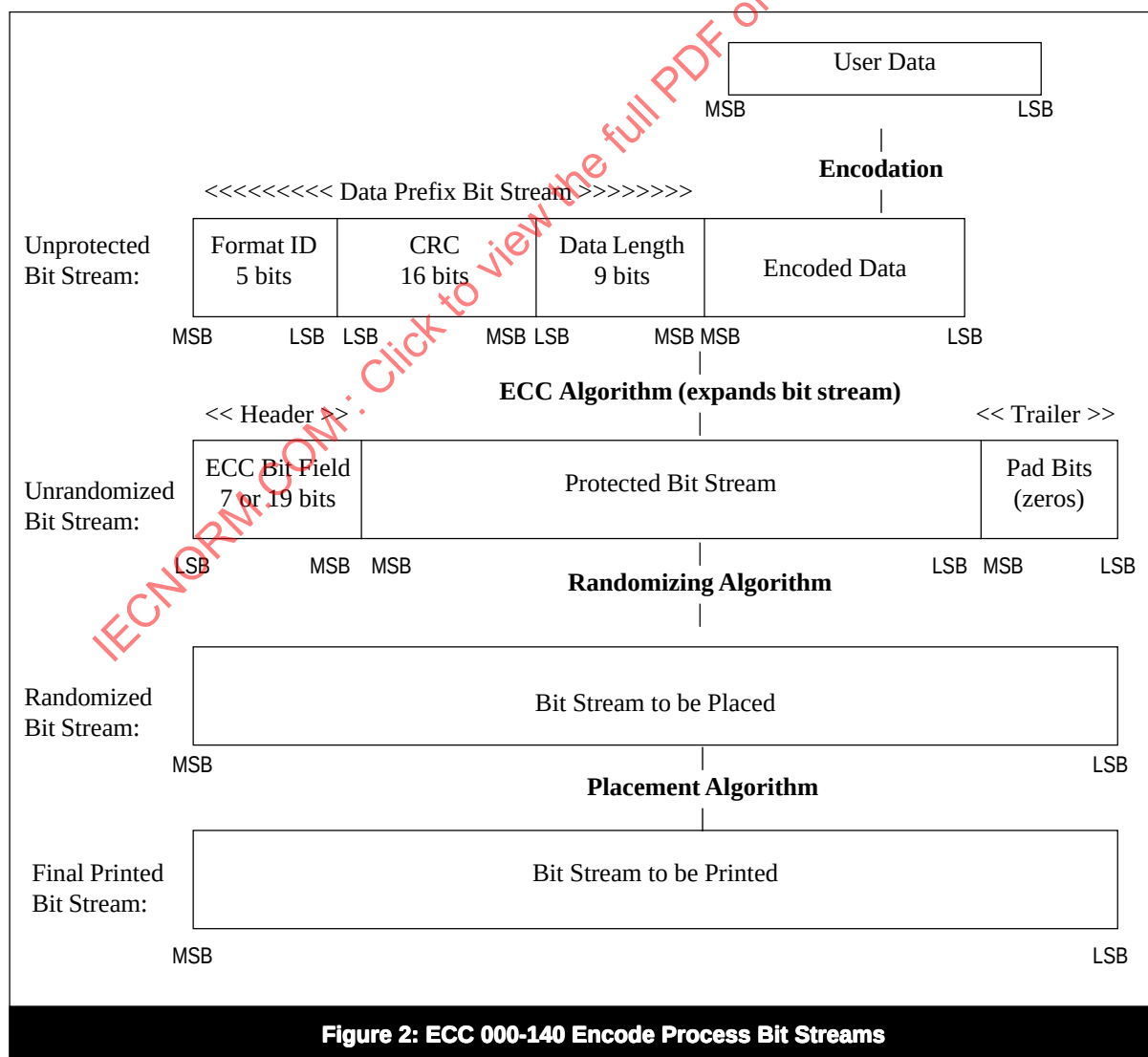
**5.2 Data Encodation**

The data shall be encoded using one of six encodation schemes (see Table 1).

The encodation scheme is fixed for the entire symbol, and thus the selection of the most appropriate encodation scheme can have a considerable effect on the number of bits required to encode any given data.

The same data may be represented in ECC 000 - 140 symbols in different ways through the use of the different encodation schemes. The character sets of all the encodation schemes, except the 8-bit byte scheme, are given in Annexe C. The 8-bit byte scheme is user definable.

The most efficient scheme to use is the lowest base number scheme which is capable of encoding all the characters in the message. Thus if all the characters can be encoded in Base 27, it is not efficient to use Base 37, Base 41 or ASCII.



To determine the appropriate encodation scheme, the data to be encoded should be analyzed. The character sets of each of the Base N encodation schemes should be compared with the data character set to be encoded starting with the Base 11 character set. If this is suitable then it should be used, if not the comparisons should continue with Base 27, Base 37 and Base 41 until the appropriate lowest level encodation scheme is found. If data characters beyond the capability of Base 41 need to be encoded, the ASCII set should be used, unless characters are beyond this; in which case the 8-bit byte set should be used.

For all encodation schemes, each compressed sequence of 4-24 bits is placed into the Encoded Bit Stream in reverse order (LSB first). This means that each individual compressed sequence is composed, then reversed, and output immediately to the Encoded Bit Stream. This does not mean that a complete compressed bit stream is formed, then reversed.

The details of each encodation scheme are given in the following clauses.

#### 5.2.1 Base 11 - Numeric Encodation

The Base 11 (Numeric) Encodation scheme encodes 6 data characters as 21 bits, achieving a encodation of 3.5 bits per data character. The Base 11 code set enables the following 11 characters to be encoded:

0 to 9  
space

The data is encoded in two stages. In the first stage, the actual data characters shall be replaced by their Base 11 code values, as given in Annexe C.

In the second phase, the Base 11 code values shall be compacted using a Base 11 to Base 2 conversion according to the procedures defined in Annexe C.1.

#### 5.2.2 Base 27 - Upper-case Alphabetic Encodation

The Base 27 (Upper-case Alphabetic) Encodation scheme encodes 5 data characters as 24 bits, achieving a encodation of 4.8 bits per data character. The Base 27 code set enables the following 27 characters to be encoded:

A to Z  
space

The data is encoded in two stages. In the first stage, the actual data characters shall be replaced by their

Base 27 code values, as given in Annexe C.

In the second stage, the Base 27 code values shall be compacted using a Base 27 to Base 2 conversion according to the procedures defined in Annexe C.2.

#### 5.2.3 Base 37 - Upper-case Alphanumeric Encodation

The Base 37 (Upper-case Alphanumeric) Encodation scheme encodes 4 data characters as 21 bits, achieving a encodation of 5.25 bits per data character. The Base 37 code set enables the following 37 characters to be encoded:

A to Z  
0 to 9  
space

The data is encoded in two stages. In the first stage, the actual data characters shall be replaced by their Base 37 code values, as given in Annexe C.

In the second stage, the Base 37 code values shall be compacted using a Base 37 to Base 2 conversion according to the procedures defined in Annexe C.3.

#### 5.2.4 Base 41 - Upper-case Alphanumeric plus Punctuation Encodation

The Base 41 (Upper-case Alphanumeric plus Punctuation) Encodation scheme encodes 4 data characters as 22 bits, achieving a encodation of 5.5 bits per data character. The Base 41 code set enables the following 41 characters to be encoded:

A to Z  
0 to 9  
space  
, (period)  
, (comma)  
- (minus or hyphen)  
/ (forward slash or solidus)

The data is encoded in two stages. In the first stage, the actual data characters shall be replaced by their Base 41 code values, as given in Annexe C.

In the second stage, the Base 41 code values shall be compacted using a Base 41 to Base 2 conversion according to the procedures defined in Annexe C.4.

#### 5.2.5 ASCII Encodation

The ASCII Encodation scheme enables all 128 characters from ANSI X3.4 to be encoded. Each data character shall be encoded as a 7-bit byte equivalent to the decimal value shown in the ASCII column of Table C1 of Annexe C.

### 5.2.6 8-bit Byte Encodation

The 8-bit Byte Encodation scheme shall be used for closed applications, where the data interpretation shall be determined by the user. Each data character shall be encoded as an 8-bit byte.

### 5.3 User Selection of Error Correction Level

### 5.3.1 Selection of Error Correction Level

ECC 000 - 140 symbols offer five levels of error correction using convolutional code error correction, as set out in Table 2. In an application, it is important to understand that these error correction levels result in the generation of a proportional increase in the number of bits in the message (and hence increase in the size of the symbol), and offer different levels of error recovery.

| Error Correction Code Level | Maximum % Damage | Increase in User Bits from ECC 0 |
|-----------------------------|------------------|----------------------------------|
| 000                         | none             | none                             |
| 050                         | 28               | 33                               |
| 080                         | 5.5              | 50                               |
| 100                         | 12.6             | 100                              |
| 140                         | 25               | 300                              |

**Table 2: Error Correction Error Recovery and Overhead Percentages**

### 5.3.2 Additional Error Correction Levels Based on Convolutional Codes

Additional levels of error correction, based on convolutional code algorithms, are possible in Data Matrix. Symbols conforming to these constructions may be found in systems implemented prior to the publication of this specification. Information on these additional Error Correction levels is available from AIM USA.

#### 5.4 Constructing the Unprotected Bit Stream

Figure 2 illustrates that the Unprotected Bit Stream has the Data Prefix Bit Stream as a prefix to the encoded data bits. The component parts of the Data Prefix Bit Stream are defined below.

#### 5.4.1 Format ID Bit Field

The format ID defines the data encodation scheme. The format ID has a decimal value for the purposes of definition and a 5-bit segment value for encoding as defined in Table 3.

| Format ID | Encodation Scheme | Binary Segment Value |     |
|-----------|-------------------|----------------------|-----|
|           |                   | MSB                  | LSB |
| 1         | Base 11           | 00000                |     |
| 2         | Base 27           | 000001               |     |
| 3         | Base 41           | 000010               |     |
| 4         | Base 37           | 00011                |     |
| 5         | ASCII             | 00100                |     |
| 6         | 8-bit Byte        | 00101                |     |

### Table 3: Encoding the Format ID

### 5.4.2 CRC Bit Field

The CRC Bit Field is generated by the CRC algorithm. The CRC Value is generated from the original user data as 8-bit bytes before encodation and so produces an independent error check on the user data. Annexe D describes the complete procedure for generating the CRC Value.

### 5.4.3 Data Length Bit Field

The Data Length Bit Field is 9 bits in length and represents, as a binary value, the number of user data characters being encoded.

#### 5.4.4 Data Prefix Construction

The Data Prefix Bit Stream is constructed as 30 bits as illustrated in Figure 3.

|                     |                      |                       |
|---------------------|----------------------|-----------------------|
| Format ID<br>5 bits | CRC Value<br>16 bits | Data Length<br>9 bits |
| MSB    LSB          | MSB    LSB           | MSB                   |

Note: Some bit fields start with the MSB others start with LSB

### Figure 3: Structure of Data Prefix Bit Stream

#### 5.4.5 Completing the Unprotected Bit Stream

The encoded data bits are added as a suffix to the Data Prefix Bit Stream to construct the Unprotected Bit Stream.

### 5.5 Constructing the Unrandomized Bit Stream

Figure 2 illustrates that the Unrandomized Bit

Stream has three constituent parts:

- a. Header
- b. Protected Bit Stream
- c. Trailer

The component parts shall be generated as defined below.

#### 5.5.1 Header Construction

The header of the Unrandomized Bit Stream contains the ECC Bit Field, which identifies the convolutional code structure used to protect the data encoded in the symbol. The ECC Bit Field is 7 or 19 bits long and the values are shown in Table 4.

| ECC Level | Binary Segment Identifier |         |
|-----------|---------------------------|---------|
|           | MSB                       | LSB     |
| 000       |                           | 1111110 |
| 050       | 0001110000000001          | 110     |
| 080       | 1110001110000001          | 110     |
| 100       | 1111111110000001          | 110     |
| 140       | 1111110001110001          | 110     |

Table 4: ECC Bit Field

#### 5.5.2 Applying Convolutional Coding to Create the Protected Bit Stream

One of the five error correction levels shall be applied. The selection criteria are defined in Section 5.3. No error correction is applied for ECC 000, so the Unprotected Bit Stream becomes the Protected Bit Stream.

For the other four error correction levels, convolutional coding is applied. This expands the user data proportionally throughout its length. The encoded bit stream shall be created by processing the unprotected bit stream through the appropriate error correction state machine and reading the results. The circuit diagrams of the four state machines for ECC 050 to 140 are given in Annexe E.

#### 5.5.3 Trailer Construction

A Trailer containing pad bits (zeros) is appended to the Protected Bit Stream. Pad bits shall be added at the end of the bit stream to ensure that the square root of the total number of bits in the Unrandomized Bit Stream shall be an odd integer between 7 and 47.

This ensures that the symbol is square.

#### 5.5.4 Completing the Unrandomized Bit Stream

The Protected Bit Stream, with the header and trailer added, is called the Unrandomized Bit Stream and is shown in Figure 2.

#### 5.6 Pattern Randomizing

The Unrandomized Bit Stream is processed by the pattern randomizing algorithm and produces the Randomized Bit Stream. The pattern randomizing algorithm consists of a bitwise XOR operation between the Unrandomized Bit Stream and the Master Random Bit Stream as given in Annexe F starting with the MSB position and continuing for the length of the Unrandomized Bit Stream.

#### 5.7 Module Placement in Matrix

The size of the sides of the data module grid is given by the odd integer square root (between 7 and 47) calculated in the procedure defined in Section 5.5.3. The Randomized Bit Stream is placed into the matrix one module at a time according to the data module placement grids given in Annexe B.

The finder pattern (as defined in Section 4.3.1) shall be placed to produce an external border to the data module grid.

## 6 ECC 200 Requirements

### 6.1 Encode Procedure Overview

This section provides an overview of the encoding procedure. Following sections will provide more details. An encoding example for ECC 200 is given in Annexe R. The following steps convert user data to an ECC 200 symbol:

#### Step 1: Data Encodation

Analyze the data stream to identify the variety of different characters to be encoded. ECC 200 includes various encodation schemes which allow a defined set of characters to be converted into codewords more efficiently than the default scheme. Insert additional codewords to switch between the encodation schemes and to perform other functions. Add pad characters as needed to fill out the required number of codewords. If the user does not specify the matrix size, then

| Encodation Scheme | Characters                        | Bits per Data Character |
|-------------------|-----------------------------------|-------------------------|
| ASCII             | double digit numerics             | 4                       |
|                   | ASCII values 0-127                | 8                       |
|                   | Extended ASCII values 128-255     | 16                      |
| C40               | Primarily upper-case alphanumeric | 5.33                    |
| Text              | Primarily lower-case alphanumeric | 5.33                    |
| X12               | ANSI X12 EDI data set             | 5.33                    |
| EDIFACT           | ASCII values 32-94                | 6                       |
| Base 256          | All byte values 0-255             | 8                       |

**Table 5: Encodation Schemes for ECC 200**

choose the smallest size that accommodates the data. A complete list of matrix sizes is shown in Section 6.5, Table 11.

#### Step 2: Error Checking and Correcting Generation

For symbols with more than 255 codewords, sub-divide the codeword stream into interleaved blocks to enable the error correction algorithms to be processed as shown in Annexe G. Generate the error correction codewords for each block. The result of this process expands the codeword stream by the number of error correction codewords. Place the error correction codewords after the data codewords.

#### Step 3: Module Placement in Matrix

Place the codeword modules in the matrix. Insert the alignment pattern modules, if any, in the matrix. Add the finder pattern modules around the matrix.

## 6.2 Data Encodation

### 6.2.1 Overview

The data may be encoded using any combination of six encodation schemes (see Table 5).

ASCII encodation is the basic scheme. All other encodation schemes are invoked from ASCII encodation and return to this scheme.

The compaction efficiencies given in Table 5 need to be interpreted carefully. The best scheme for a given set of data may not be the one with the fewest bits per data character. If the highest degree of compaction is required, account has to be taken of switching between code sets and of switching to and from encodation schemes (see Annexe S). It should also be noted that even if the number of codewords is minimized, the codeword stream may need to be expanded to fill a symbol. This fill process is done using pad characters.

### 6.2.2 Default Character Interpretation

The default character interpretation for character values 0 to 127 shall conform to ANSI X3.4. The default character interpretation for character values 128 to 255 shall conform to ISO 8859-1: Latin Alphabet No. 1. The graphical representation of data characters shown throughout this document complies with the default interpretation. This interpretation can be changed using Extended Channel Interpretation (ECI) escape sequences, see Section 6.4. The default interpretation corresponds to ECI 000003.

### 6.2.3 ASCII Encodation

ASCII encodation is the default set for the first symbol character in all symbol sizes. It encodes ASCII data, double density numeric data and symbology control characters.

Symbology control characters include function characters, the pad character and the switches to other code sets.

ASCII data is encoded as codewords 1 to 128 (ASCII value plus 1). Extended ASCII (data values 128 to 255) is encoded using the upper shift symbology control character (see Section 6.2.4.2). The digit pairs 00 to 99 are encoded with codewords 130 to 229 (numeric value plus 130). The ASCII code assignments are shown in Table 6.

| Codeword | Data or Function                         |
|----------|------------------------------------------|
| 1-128    | ASCII data (ASCII value + 1)             |
| 129      | Pad                                      |
| 130-229  | 2-digit data 00-99 (Numeric Value + 130) |
| 230      | Latch to C40 Encodation                  |
| 231      | Latch to Base 256 Encodation             |
| 232      | FNC1                                     |
| 233      | Structured Append                        |
| 234      | Reader Programming                       |
| 235      | Upper Shift (shift to Extended ASCII)    |
| 236      | 05 Macro                                 |
| 237      | 06 Macro                                 |
| 238      | Latch to ANSI X12 Encodation             |
| 239      | Latch to Text Encodation                 |
| 240      | Latch to EDIFACT Encodation              |
| 241      | ECI Character                            |

**Table 6: ASCII Encodation Values**

#### 6.2.4 Symbology Control Characters

ECC 200 symbols have several special symbology control characters, which have particular significance to the encodation scheme. These characters shall be used to instruct the decoder to perform certain functions or to send specific data to the host computer as described in Section 6.2.4.1 to 6.2.4.9. These symbology control characters are found predominantly in the ASCII encodation set.

##### 6.2.4.1 Latch Characters

A Latch Character shall be used to switch from ASCII encodation to one of the other encodation schemes. All codewords which follow a Latch Character shall be compacted according to the new encodation scheme.

The encodation schemes have different methods for returning to the ASCII encodation set.

##### 6.2.4.2 Upper Shift Character

The Upper Shift character is used to encode a single extended ASCII character (values 128-255). An extended ASCII character encoded in the ASCII, C40, or Text encodation scheme requires a preceding Upper Shift character and the extended ASCII character value decreased by 128 is then encoded according to the rules of the code set.

In ASCII encodation, the Upper Shift character is represented by codeword 235. The reduced data

value (i.e. ASCII value - 128) is transformed into its codeword value by adding 1.

For example, to encode ¥ (ASCII value 165), an Upper Shift character (Codeword 235) is followed by value 37 (165 - 128), which is encoded as codeword 38.

If there are long data strings of characters from the extended ASCII range, a Latch to Base 256 Encodation should be more efficient.

##### 6.2.4.3 Pad Character

If the encoded data, irrespective of the encodation scheme in force, does not fill the data capacity of the symbol, pad characters shall be added (prefixed by codeword 254 or Unlatch if necessary) to fill out the remaining data capacity of the symbol. The pad characters shall only be used for this purpose.

The 253-State pattern randomizing algorithm is applied to the pad characters starting at the second pad character and continuing to the end of the symbol (see Annexe H.1).

##### 6.2.4.4 Extended Channel Interpretation Character

An Extended Channel Interpretation (ECI) character is used to change from the default interpretation used to encode data. The Extended Channel Interpretation protocol is common across a number of symbologies and its application to ECC 200 is defined more fully in Section 6.4.

The ECI character shall be followed by one, two, or three codewords which identify the ECI being invoked. The new ECI remains in place until the end of the encoded data, or until another ECI character is used to invoke another interpretation.

##### 6.2.4.5 Shift Characters in C40 and Text Encodation

The three shift characters in C40 and Text encodation are used to switch for a single data character to one of the subsets of these encodation schemes.

##### 6.2.4.6 FNC1 Alternate Data Type Identifier

To encode data to conform to specific industry standards as authorized by AIM International, a FNC1 character shall appear in the first or second symbol character position (or in the fifth or sixth data positions of the first symbol of Structured Append). FNC1 encoded in any other position is used as a field separator and shall be transmitted as GS control character (ASCII value 29).

#### 6.2.4.7 Macro Characters

Data Matrix provides a means of abbreviating an industry specific header and trailer in one symbol character. This feature exists to reduce the number of symbol characters needed to encode data in a symbol using certain structured formats.

The two Macro characters apply only when in the first symbol character position. They shall not be used in conjunction with Structured Append and their functions are defined in Table 7. The header will be transmitted as a prefix to the data stream and the trailer will be transmitted as a suffix to the data stream. The symbology identifier, if used, will precede the header.

| Macro Codeword | Name     | Interpretation          |                     |
|----------------|----------|-------------------------|---------------------|
|                |          | Header                  | Trailer             |
| 236            | 05 Macro | $\text{D} >^R_s 05^G_s$ | $^R_s \text{E}_O_T$ |
| 237            | 06 Macro | $\text{D} >^R_s 06^G_s$ | $^R_s \text{E}_O_T$ |

**Table 7: Macro Functions**

#### 6.2.4.8 Structured Append Character

A Structured Append character is used to indicate that the symbol is part of a Structured Append according to the rules defined in Section 6.6.

#### 6.2.4.9 Reader Programming Character

A Reader Programming character indicates that the symbol encodes a message used to program the reader system. The Reader Programming character should appear as the first codeword and Reader

Programming should not be used with Structured Append.

#### 6.2.5 C40 Encodation

C40 encodation enables three alphanumeric data characters to be packed into two codewords. The upper-case alphabetic characters, numerics and space can each be encoded as a single C40 value. All other ASCII characters and special characters require two C40 values starting with one of three shift characters. A C40 shift character only affects the single C40 value following the shift character. The full C40 character set assignments are shown in Annexe J.1.

##### 6.2.5.1 Switching to and from C40 Encodation

It is possible to switch to C40 encodation from ASCII encodation using the appropriate latch codeword (230).

Codeword 254 immediately following a pair of codewords in C40 encodation acts as an Unlatch codeword to switch back to ASCII encodation. Otherwise, the C40 encodation remains in effect to the end of the data encoded in the symbol.

##### 6.2.5.2 C40 Encodation Rules

Each pair of codewords represents a 16-bit value where the first codeword represents the most significant 8 bits. Three C40 values ( $C_1$ ,  $C_2$ ,  $C_3$ ) shall be encoded as:

$$(1600 * C_1) + (40 * C_2) + C_3 + 1$$

which produces a value 1 to 64000. Figure 4 illustrates three C40 values compacted into two codewords.

Characters in the Shift 1, Shift 2 and Shift 3 sets shall be encoded by first encoding the appropriate

|                                      |                                            |
|--------------------------------------|--------------------------------------------|
| Data Characters                      | AIM                                        |
| C40 Values                           | 14, 22, 26                                 |
| Calculate 16-bit value               | $(1600 * 14) + (40 * 22) + 26 + 1 = 23307$ |
| 1st Codeword: (16-bit value) div 256 | $23307 \text{ div } 256 = 91$              |
| 2nd Codeword: (16-bit value) mod 256 | $23307 \text{ mod } 256 = 11$              |
| Codewords                            | 91, 11                                     |

**Figure 4: Example of C40 Encoding**

shift character, and then the C40 value for the data.

C40 encodation may be in effect at the end of the symbol's codewords which encode data. The following rules apply when only one or two symbol characters remain in the symbol before the start of the error correction codewords:

- a. If two symbol characters remain and three C40 values remain to be encoded (which may include both data and shift characters) encode the three C40 values in the last two symbol characters. A final Unlatch codeword is not required.
- b. If two symbol characters remain and two C40 values remain to be encoded (the first C40 value may be a shift or data character but the second must represent a data character); encode the two remaining C40 values followed by a pad C40 value of 0 (Shift 1) in the last two symbol characters. A final Unlatch codeword again is not required.
- c. If two symbol characters remain and only one C40 value (data character) remains to be encoded, the first symbol character is encoded as an Unlatch character and the last symbol character is encoded with the data character using the ASCII encodation scheme.
- d. If one symbol character remains and one C40 value (data character) remains to be encoded, the last symbol character is encoded with the data character using the ASCII encodation scheme. The Unlatch character is not encoded, but is assumed, before the last symbol character whenever an odd number of symbol characters remain in the symbol in the C40 encodation scheme.

In all other cases, either an Unlatch character is used to exit the C40 encodation scheme before the end of the symbol, or a larger symbol size is required to encode the data.

#### 6.2.5.3 Use of Upper Shift with C40

In C40 encodation the Upper Shift character is not a symbology function character but a shift within the encodation set. When a data character from the extended ASCII character range is encountered, three or four values in C40 encodation need to be encoded according to the following rule:

IF [ASCII value - 128] is in the Basic Set then:  
[1(Shift 2)][30(Upper Shift)][V(ASCII value -

128)]

ELSE

[1(Shift 2)][30(Upper Shift)][0, 1, or 2(Shift 1, 2, or 3)][V(ASCII value - 128)]

In the rule the number in [ ] equates to the C40 values from Annexe J.1; V has been used to indicate the appropriate C40 value.

#### 6.2.6 Text Encodation

Text encodation is designed to encode normal printed text, which is predominantly lowercase characters. It is similar in structure to the C40 encodation set, except that lowercase alphabetic characters are directly encoded (i.e. without using a shift). Upper-case alphabetic characters are preceded by a Shift 3. The full Text encodation character set assignments are shown in Annexe J.2.

##### 6.2.6.1 Switching to and from Text Encodation

It is possible to switch to Text encodation from ASCII encodation using the appropriate latch codeword (239).

Codeword 254 immediately following a pair of codewords in text encodation acts as an Unlatch codeword to switch back to ASCII encodation. Otherwise, the Text encodation remains in effect to the end of the data encoded in the symbol.

##### 6.2.6.2 Text Encodation Rules

The rules for C40 encodation apply.

##### 6.2.7 ANSI X12 Encodation

ANSI X12 encodation is used to encode the standard ANSI X12 electronic data interchange characters, which are compacted three data characters to two codewords in a manner similar to C40 encodation. It encodes upper-case alphabetic characters, numerics, space and the three standard ANSI X12 terminator and separator characters. The ANSI X12 code assignments are shown in Table 8. There are no shift characters in the ANSI X12 encodation set.

| X12 Value | Encoded Characters          | ASCII Values |
|-----------|-----------------------------|--------------|
| 0         | X12 segment terminator <CR> | 13           |
| 1         | X12 segment separator *     | 42           |
| 2         | X12 subelement separator >  | 62           |
| 3         | space                       | 32           |
| 4-13      | 0-9                         | 48-57        |
| 14-39     | A-Z                         | 65-90        |

Table 8: ANSI X12 Encodation Set

#### 6.2.7.1 Switching to and from ANSI X12 Encodation

It is possible to switch to ANSI X12 encodation from ASCII encodation using the appropriate latch codeword (238).

Codeword 254 immediately following a pair of codewords in ANSI X12 encodation acts as an Unlatch codeword to switch back to ASCII encodation. Otherwise, the ANSI X12 encodation remains in effect to the end of the data encoded in the symbol.

#### 6.2.7.2 ANSI X12 Encodation Rules

| Data Character | ASCII         |                    | EDIFACT Value |
|----------------|---------------|--------------------|---------------|
|                | Decimal Value | 8-bit Binary Value |               |
| A              | 65            | 01000001           | 000001        |
| 9              | 57            | 00111001           | 111001        |

Note: During the decode process, if the leading (6th) bit is 1, the bits 00 are prefixed to create the 8-bit byte. If the leading (6th) bit is 0, the bits 01 are prefixed to create the 8-bit byte.

The exception to this is the EDIFACT value 011111 which is the symbology control Unlatch character to return to ASCII encodation.

Figure 5: The Relationship Between the EDIFACT Value and the 8-bit Byte Value

| Data characters            | D           | A           | T           | A        |
|----------------------------|-------------|-------------|-------------|----------|
| Binary values (Annexe J.3) | 00 01 00    | 00 00 01    | 01 01 00    | 00 00 01 |
| Divide into 3 8-bit bytes  | 00 01 00 00 | 00 01 01 01 | 00 00 00 01 |          |
| Codeword values            | 16          | 21          | 1           |          |

Figure 6: Example of EDIFACT Encodation

The rules of C40 encodation apply. The exception is at the end of encoding ANSI X12 data. If the data characters do not fully utilize pairs of codewords, then following the last complete pair of codewords switch to ASCII using codeword 254 and continue using ASCII encodation, except when a single symbol character is left at the end before the first error correction character. This single symbol character uses the ASCII encodation scheme without requiring an Unlatch codeword.

#### 6.2.8 EDIFACT Encodation

The EDIFACT encodation scheme includes 63 ASCII values (values from 32 to 94) plus an Unlatch character (binary 011111) to return to ASCII encodation. EDIFACT encodation encodes four data characters in three codewords. It includes all the numeric, alphabetic and punctuation characters defined in the EDIFACT Level A character set without any of the shifts required in C40 encodation.

##### 6.2.8.1 Switching to and from EDIFACT Encodation

It is possible to switch to EDIFACT encodation from

ASCII encodation using the appropriate latch codeword (240).

The Unlatch character in EDIFACT encodation shall be used as a terminator at the end of EDIFACT encodation, which reverts to ASCII encodation.

#### 6.2.8.2 EDIFACT Encodation Rules

The EDIFACT encodation character set is defined in Annexe J.3. There is a simple relationship between the 6-bit EDIFACT value and the ASCII 8-bit byte. The leading two bits of the 8-bit byte are ignored to create the EDIFACT 6-bit value, as illustrated in Figure 5.

Strings of four EDIFACT characters are encoded in three codewords. For a simple encodation process, the leading two bits of the 8-bit byte are removed. The remaining 6-bit byte is the EDIFACT value and shall be directly encoded into the codeword as illustrated in Figure 6.

When EDIFACT Encodation is terminated with the Unlatch character, any remaining bits left in the single symbol character shall be filled with zeros. ASCII mode starts with the next symbol character. If EDIFACT Encodation is in effect at the end of the symbol before the first error correction character, and only one or two codewords remain after the last EDIFACT codeword triplet, these remaining codewords shall be encoded in ASCII Encodation without requiring an Unlatch character.

#### 6.2.9 Base 256 Encodation

The Base 256 encodation scheme shall be used to encode any 8-bit byte data, including extended channel interpretations and binary data. The default interpretation is defined in 6.2.2

The 255-State pattern randomizing algorithm is applied to each Base 256 sequence within the encoded data (see Annexe H.2). It starts after the latch to Base 256 encodation and ends at the last character specified by the Base 256 field length.

##### 6.2.9.1 Switching to and from Base 256 Encodation

It is possible to switch to Base 256 encodation from ASCII encodation using the appropriate latch codeword (231). At the end of Base 256 encodation, encodation automatically reverts to ASCII encodation.

The appropriate ECI, if other than the default, shall be invoked prior to switching. The ECI sequence need not occur immediately before switching to Base 256 encodation.

#### 6.2.9.2 Base 256 Encodation Rules

After switching to Base 256 encodation, the first one (d1) or two (d1, d2) codewords define the data field length in bytes. Table 9 specifies how the field length is defined.

Thereafter, all encodation shall be of the byte values.

| Field Length        | Values of d1,d2                                    | Permitted Values of d            |
|---------------------|----------------------------------------------------|----------------------------------|
| Remainder of Symbol | d1 = 0                                             | d1 = 0                           |
| 1 to 249            | d1 = length                                        | d1 = 1 to 249                    |
| 250 to 1555         | d1 = (length DIV 250) + 249<br>d2 = length MOD 250 | d1 = 250 to 255<br>d2 = 0 to 249 |

**Table 9: Base 256 field Length**

### 6.3 User Considerations

ECC 200 offers flexibility in the way data is encoded. Alternate character sets may be invoked using the ECI protocol. Data may be encoded in square or rectangular symbols. It is also possible to append up to 16 ECC 200 symbols.

#### 6.3.1 User Selection of Extended Channel Interpretation

The use of an alternative Extended Channel Interpretation to identify a particular code page or more specific data interpretation requires additional codewords to invoke the feature. The use of the Extended Channel Interpretation protocol (see Section 6.4) provides the capability to encode data from alphabets other than the Latin alphabet (ISO 8859-1 Latin Alphabet No. 1) supported by the default interpretation (ECI 000003).

#### 6.3.2 User Selection of Symbol Size and Shape

ECC 200 has twenty-four square and six rectangular symbol configurations. The size and shape may be selected to suit the requirement of the application. These configurations are technically specified in Section 6.5.

### 6.4 Extended Channel Interpretation

The Extended Channel Interpretation (ECI) protocol allows the output data stream to have interpretations

different from that of the default character set. The ECI protocol is defined consistently across a number of symbolologies. Four broad types of interpretations are supported in Data Matrix:

- international character sets (or code pages)
- general purpose interpretations such as encryption and compaction
- user defined interpretations for closed systems
- control information for structured append in unbuffered mode.

The Extended Channel Interpretation protocol is fully specified in the *Extended Channel Interpretation (ECI) Assignments* document. The protocol provides a consistent method to specify particular interpretations on byte values before printing and after decoding.

The Extended Channel Interpretation is identified by a 6-digit number which is encoded in the Data Matrix symbol by the ECI character followed by one to three codewords.

The Extended Channel Interpretation can only be used with readers enabled to transmit the symbology identifiers. Readers that are not enabled to transmit the symbology identifier shall not transmit the data from any symbol containing an ECI. An exception can be made if the ECI(s) can be handled entirely within the reader.

The Extended Channel Interpretation protocol shall only be applied to ECC 200 symbols. A specified Extended Channel Interpretation may be invoked anywhere in the encoded message.

#### 6.4.1 Encoding ECIs

The various encodation schemes of Data Matrix for ECC 200 (defined in Table 5) may be applied under

any of the Extended Channel Interpretations. The ECI can only be invoked from ASCII encodation; once this has occurred, switching may take place between any of the encodation schemes. The encodation mode used is determined strictly by the 8-bit data values being encoded and does not depend on the Extended Channel Interpretation in force. For example, a sequence of values in the range 48 to 57 (decimal) would be most efficiently encoded in numeric mode even if they are not to be interpreted as numbers.

The ECI assignment is invoked using codeword 241 (ECI character) in ASCII encodation. One, two, or three additional codewords are used to encode the ECI Assignment number. The encodation rules are defined in Table 10.

The following examples illustrate the encodation:

ECI = 015000

Codewords: [241] [(15000 - 127) div 254 + 128] [(15000 - 127) mod 254 + 1]

= [241][58 + 128][141 + 1]

= [241][186][142]

ECI = 090000

Codewords: [241] [(90000 - 16383) div 64516 + 192] [(90000 - 16383) div 254 mod 254 + 1] [(90000 - 16383) mod 254 + 1]

= [241][1 + 192][289 mod 254 + 1][211 + 1]

= [241][193][36][212]

#### 6.4.2 ECIs and Structured Append

ECIs may occur anywhere in the message encoded in a single or Structured Append (see Section 6.6) set

| ECI Assignment Value | Codeword Sequence                                                    | Codeword Values                                                                                                   | Ranges                                                                                      |
|----------------------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| 000000 to 000126     | C <sub>0</sub><br>C <sub>1</sub>                                     | 241<br>ECI_no + 1                                                                                                 | C <sub>1</sub> = (1 to 127)                                                                 |
| 000127 to 016382     | C <sub>0</sub><br>C <sub>1</sub><br>C <sub>2</sub>                   | 241<br>(ECI_no - 127) div 254 + 128<br>(ECI_no - 127) mod 254 + 1                                                 | C <sub>1</sub> = (128 to 191)<br>C <sub>2</sub> = (1 to 254)                                |
| 0016383 to 999999    | C <sub>0</sub><br>C <sub>1</sub><br>C <sub>2</sub><br>C <sub>3</sub> | 241<br>(ECI_no - 16383) div 64516 + 192<br>[(ECI_no - 16383) div 254] mod 254 + 1<br>(ECI_no - 16383) mod 254 + 1 | C <sub>1</sub> = (192 to 207)<br>C <sub>2</sub> = (1 to 254)<br>C <sub>3</sub> = (1 to 254) |

**Table 10: Encoding ECI Assignment Numbers in ECC 200**

| Symbol Size <sup>1</sup>                                                                                                                                                                                                                                                                                                                  |     | Data Region |        | Mapping Matrix | Total Codewords |       | Reed-Solomon Block |       | Inter-leaved | Data Capacity |                |           | Error Correction | Max. Correctable       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------------|--------|----------------|-----------------|-------|--------------------|-------|--------------|---------------|----------------|-----------|------------------|------------------------|
| Row                                                                                                                                                                                                                                                                                                                                       | Col | Size        | Number | Size           | Data            | Error | Data               | Error | Blocks       | Num. Cap.     | Alphanum. Cap. | Byte Cap. | Overhead %       | Codeword Error/Erasure |
| 10                                                                                                                                                                                                                                                                                                                                        | 10  | 8x8         | 1      | 8x8            | 3               | 5     | 3                  | 5     | 1            | 6             | 3              | 1         | 62.5             | 2/+                    |
| 12                                                                                                                                                                                                                                                                                                                                        | 12  | 10x10       | 1      | 10x10          | 5               | 7     | 5                  | 7     | 1            | 10            | 6              | 3         | 58.3             | 3/+                    |
| 14                                                                                                                                                                                                                                                                                                                                        | 14  | 12x12       | 1      | 12x12          | 8               | 10    | 8                  | 10    | 1            | 16            | 10             | 6         | 55.6             | 5/7                    |
| 16                                                                                                                                                                                                                                                                                                                                        | 16  | 14x14       | 1      | 14x14          | 12              | 12    | 12                 | 12    | 1            | 24            | 16             | 10        | 50               | 6/9                    |
| 18                                                                                                                                                                                                                                                                                                                                        | 18  | 16x16       | 1      | 16x16          | 18              | 14    | 18                 | 14    | 1            | 36            | 25             | 16        | 43.8             | 7/11                   |
| 20                                                                                                                                                                                                                                                                                                                                        | 20  | 18x18       | 1      | 18x18          | 22              | 18    | 22                 | 18    | 1            | 44            | 31             | 20        | 45               | 9/15                   |
| 22                                                                                                                                                                                                                                                                                                                                        | 22  | 20x20       | 1      | 20x20          | 30              | 20    | 30                 | 20    | 1            | 60            | 43             | 28        | 40               | 10/17                  |
| 24                                                                                                                                                                                                                                                                                                                                        | 24  | 22x22       | 1      | 22x22          | 36              | 24    | 36                 | 24    | 1            | 72            | 52             | 34        | 40               | 12/21                  |
| 26                                                                                                                                                                                                                                                                                                                                        | 26  | 24x24       | 1      | 24x24          | 44              | 28    | 44                 | 28    | 1            | 88            | 64             | 42        | 38.9             | 14/25                  |
| 32                                                                                                                                                                                                                                                                                                                                        | 32  | 14x14       | 4      | 28x28          | 62              | 36    | 62                 | 36    | 1            | 124           | 91             | 60        | 36.7             | 18/33                  |
| 36                                                                                                                                                                                                                                                                                                                                        | 36  | 16x16       | 4      | 32x32          | 86              | 42    | 86                 | 42    | 1            | 172           | 127            | 84        | 32.8             | 21/39                  |
| 40                                                                                                                                                                                                                                                                                                                                        | 40  | 18x18       | 4      | 36x36          | 114             | 48    | 114                | 48    | 1            | 228           | 169            | 112       | 29.6             | 24/45                  |
| 44                                                                                                                                                                                                                                                                                                                                        | 44  | 20x20       | 4      | 40x40          | 144             | 56    | 144                | 56    | 1            | 288           | 214            | 142       | 28               | 28/53                  |
| 48                                                                                                                                                                                                                                                                                                                                        | 48  | 22x22       | 4      | 44x44          | 174             | 68    | 174                | 68    | 1            | 348           | 259            | 172       | 28.1             | 34/65                  |
| 52                                                                                                                                                                                                                                                                                                                                        | 52  | 24x24       | 4      | 48x48          | 204             | 84    | 102                | 42    | 2            | 408           | 304            | 202       | 29.2             | 42/78                  |
| 64                                                                                                                                                                                                                                                                                                                                        | 64  | 14x14       | 16     | 56x56          | 280             | 112   | 140                | 56    | 2            | 560           | 418            | 278       | 28.6             | 56/106                 |
| 72                                                                                                                                                                                                                                                                                                                                        | 72  | 16x16       | 16     | 64x64          | 368             | 144   | 92                 | 36    | 4            | 736           | 550            | 366       | 28.1             | 72/132                 |
| 80                                                                                                                                                                                                                                                                                                                                        | 80  | 18x18       | 16     | 72x72          | 456             | 192   | 114                | 48    | 4            | 912           | 682            | 454       | 29.6             | 96/180                 |
| 88                                                                                                                                                                                                                                                                                                                                        | 88  | 20x20       | 16     | 80x80          | 576             | 224   | 144                | 56    | 4            | 1152          | 862            | 574       | 28               | 112/212                |
| 96                                                                                                                                                                                                                                                                                                                                        | 96  | 22x22       | 16     | 88x88          | 696             | 272   | 174                | 68    | 4            | 1392          | 1042           | 694       | 28.1             | 136/260                |
| 104                                                                                                                                                                                                                                                                                                                                       | 104 | 24x24       | 16     | 96x96          | 816             | 336   | 136                | 56    | 6            | 1632          | 1222           | 814       | 29.2             | 168/318                |
| 120                                                                                                                                                                                                                                                                                                                                       | 120 | 18x18       | 36     | 108x108        | 1050            | 408   | 175                | 68    | 6            | 2100          | 1573           | 1048      | 28               | 204/390                |
| 132                                                                                                                                                                                                                                                                                                                                       | 132 | 20x20       | 36     | 120x120        | 1304            | 496   | 163                | 62    | 8            | 2608          | 1954           | 1302      | 27.6             | 248/472                |
| 144                                                                                                                                                                                                                                                                                                                                       | 144 | 22x22       | 36     | 132x132        | 1558            | 620   | 156                | 62    | 8*           | 3116          | 2335           | 1556      | 28.5             | 310/590                |
|                                                                                                                                                                                                                                                                                                                                           |     |             |        |                |                 |       | 155                | 62    | 2*           |               |                |           |                  |                        |
| Rectangular Symbols                                                                                                                                                                                                                                                                                                                       |     |             |        |                |                 |       |                    |       |              |               |                |           |                  |                        |
| 8                                                                                                                                                                                                                                                                                                                                         | 18  | 6x16        | 1      | 6x16           | 5               | 7     | 5                  | 7     | 1            | 10            | 6              | 3         | 58.3             | 3/+                    |
| 8                                                                                                                                                                                                                                                                                                                                         | 32  | 6x14        | 2      | 6x28           | 10              | 11    | 10                 | 11    | 1            | 20            | 13             | 8         | 52.4             | 5/+                    |
| 12                                                                                                                                                                                                                                                                                                                                        | 26  | 10x24       | 1      | 10x24          | 16              | 14    | 16                 | 14    | 1            | 32            | 22             | 14        | 46.7             | 7/11                   |
| 12                                                                                                                                                                                                                                                                                                                                        | 36  | 10x16       | 2      | 10x32          | 22              | 18    | 22                 | 18    | 1            | 44            | 31             | 20        | 45.0             | 9/15                   |
| 16                                                                                                                                                                                                                                                                                                                                        | 36  | 14x16       | 2      | 14x32          | 32              | 24    | 32                 | 24    | 1            | 64            | 46             | 30        | 42.9             | 12/21                  |
| 16                                                                                                                                                                                                                                                                                                                                        | 48  | 14x22       | 2      | 14x44          | 49              | 28    | 49                 | 28    | 1            | 98            | 72             | 47        | 36.4             | 14/25                  |
| Note 1: Symbol size does not include quiet zone.<br>*Note: In the largest symbol (144x144), the first eight Reed-Solomon blocks shall be 218 codewords long encoding 156 data codewords. The last two blocks shall encode 217 codewords (155 data codewords). All the blocks have 62 error correction codewords.<br>+Note: Does not apply |     |             |        |                |                 |       |                    |       |              |               |                |           |                  |                        |
| Table 11: ECC 200 Symbol Attributes                                                                                                                                                                                                                                                                                                       |     |             |        |                |                 |       |                    |       |              |               |                |           |                  |                        |

of Data Matrix symbols. Any ECI invoked shall apply until the end of the encoded data, or until another ECI is encountered. Thus the interpretation of the ECI may straddle two or more symbols.

#### 6.4.3 Post-Decode Protocol

The protocol for transmitting ECI data shall be as defined in Section 11.4. When using ECIs, symbology identifiers (see Section 11.5) shall be fully implemented and the appropriate symbology identifier transmitted as a preamble.

### 6.5 ECC 200 Symbol Attributes

#### 6.5.1 Symbol Sizes and Capacity

There are 24 square symbols and 6 rectangular symbols available in ECC 200. These are as specified in Table 11.

#### 6.5.2 Insertion of Alignment Patterns into Larger Symbols

As shown in Table 11, square symbols 32x32 and larger and four rectangular symbols (8 x 32, 12 x 36, 16 x 36, and 16 x 48) have two or more data regions. The square symbols are divided into 4, 16, or 36 data regions (as illustrated in Annexe K.1, K.2, and K.3). The rectangular symbols are divided into two data regions (as illustrated in Annexe K.4). These data regions are bounded by alignment patterns. The alternating dark modules of the alignment pattern shall be to the top and right of a data region and identify the even columns and rows.

### 6.6 Structured Append

#### 6.6.1 Basic Principles

Up to 16 ECC 200 symbols may be appended in a structured format. If a symbol is part of a Structured Append, this is indicated by codeword 233 in the first symbol character position. This is immediately followed by three structured append codewords. The first codeword is the symbol sequence indicator. The second and third codewords are the file identification.

#### 6.6.2 Symbol Sequence Indicator

This codeword indicates the position of the symbol within the set (up to 16) of ECC 200 symbols in the Structured Append format in the form  $m$  of  $n$  symbols.

The first 4 bits of this codeword identify the position of the particular symbol as the binary value of  $(m-1)$ . The last 4 bits identify the total number of

the symbols to be concatenated in the Structured Append format as the binary value of  $(17-n)$ . The 4-bit patterns shall conform to those defined in Table 12.

#### Example:

To indicate the 3rd symbol of a set of 7, this shall be encoded thus:

|                  |          |
|------------------|----------|
| 3rd position:    | 0010     |
| Total 7 symbols: | 1010     |
| Bit pattern:     | 00101010 |
| Codeword value:  | 42       |

#### 6.6.3 File Identification

The file identification is defined by the value of its two codewords. Each file identification codeword may have a value 1 to 254, allowing 64516 different file identifications. The purpose of the file identification is to increase the probability that only logically linked symbols are processed as part of the same message.

| Symbol Position | Bits 1234 | Total Number of Symbols | Bits 5678 |
|-----------------|-----------|-------------------------|-----------|
| 1               | 0000      |                         |           |
| 2               | 0001      | 2                       | 1111      |
| 3               | 0010      | 3                       | 1110      |
| 4               | 0011      | 4                       | 1101      |
| 5               | 0100      | 5                       | 1100      |
| 6               | 0101      | 6                       | 1011      |
| 7               | 0110      | 7                       | 1010      |
| 8               | 0111      | 8                       | 1001      |
| 9               | 1000      | 9                       | 1000      |
| 10              | 1001      | 10                      | 0111      |
| 11              | 1010      | 11                      | 0110      |
| 12              | 1011      | 12                      | 0101      |
| 13              | 1100      | 13                      | 0100      |
| 14              | 1101      | 14                      | 0011      |
| 15              | 1110      | 15                      | 0010      |
| 16              | 1111      | 16                      | 0001      |

**Table 12: Structured Append Symbol Position Bits**

#### 6.6.4 FNC1 and Structured Append

If Structured Append is used in conjunction with FNC1 (see Section 6.2.4.6), the first four codewords

shall be used for Structured Append and the fifth and sixth codewords are available for FNC1 usage. FNC1 shall not be repeated in these positions in the second and subsequent symbols, except when used as a field separator.

#### 6.6.5 Buffered and Unbuffered Operation

The message within a Structured Append sequence can be buffered in the reader in its entirety and transmitted after all of the symbols have been read. Alternatively, the reader may transmit the decoded data in each symbol as it is read. In this unbuffered operation, the ECI protocol for structured append defines a control block that shall be prefixed to the beginning of each transmission.

#### 6.7 Error Detection and Correction

ECC 200 symbols employ Reed-Solomon error correction.

For ECC 200 symbols with less than 255 total codewords, the error correction codewords are calculated from data codewords with no interleaving.

For ECC 200 symbols with more than 255 total codewords, the error correction codewords are calculated from data codewords with the interleaving procedure described in Annexe G.

Each ECC 200 symbol employs a specific combination of interleaving and number of error correction codewords. These combinations are given in Table 11.

The polynomial arithmetic for ECC 200 shall be calculated using bit-wise modulo 2 arithmetic and byte-wise modulo 100101101 (decimal 301) arithmetic. This is a Galois field of  $2^8$  with 100101101 representing the field's prime modulus polynomial:  $x^8 + x^5 + x^3 + x^2 + 1$ .

Sixteen different generator polynomials are used for generating the appropriate error correction codewords. These are given in Annexe L.1.

##### 6.7.1 Generating the Error Correction Codewords

The error correction codewords are the remainder after dividing the data codewords by a polynomial  $g(x)$  used for Reed-Solomon codes (see Annexe L.1).

The data codewords are the coefficients of the terms of a polynomial with the coefficient of the highest term being the first data codeword and the lowest power term being the last data codeword

before the first error correction codeword. The highest order coefficient of the remainder is the first error correction codeword and the zero power coefficient is the last error correction codeword and the last codeword.

This can be implemented by using the division circuit as shown in Figure 7. The registers  $b_0$  through  $b_{k-1}$  are initialized as zeros. There are two phases to generate the encoding. In the first phase, with the switch in the down position the data codewords are passed both to the output and the circuit. The first phase is complete after  $n$  clock pulses. In the second phase ( $n+1 \dots n+k$  clock pulses), with the switch in the up position, the error correction codewords  $e_{k-1} \dots e_0$  are generated by flushing the registers in order and complementing the output while keeping the data input at 0. The codewords output from the shift register are in the order that they are to be placed in the symbol. If interleaving is used, the codewords will not be placed in consecutive symbol characters. (See Annexe G).

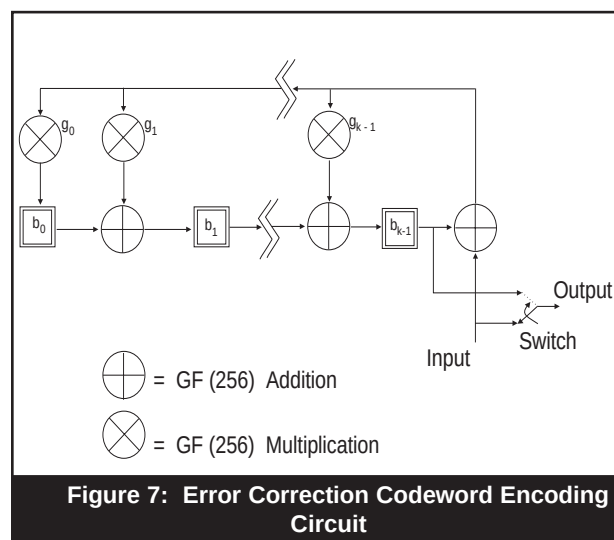


Figure 7: Error Correction Codeword Encoding Circuit

##### 6.7.2 Error Correction Capacity

The error correction codewords can correct two types of erroneous codewords: erasures (erroneous codewords at known locations) and errors (erroneous

codewords at unknown locations). An erasure is an unscanned or undecodable symbol character. An error is a misdecoded symbol character. The number of erasures and errors correctable is given by the following formula:

$$e + 2t \leq d - p$$

where:

- e = number of erasures
- t = number of errors
- d = number of error correction codewords
- p = number of codewords reserved for error detection.

In the general case,  $p = 0$ . However, if most of the error correction capacity is used to correct erasures, then the possibility of an undetected error is increased. Whenever the number of erasures is more than half the number of error correction codewords,  $p = 3$ . For small symbols (10x10, 12x12, 8x18, and 8x32), erasure correction should not be used ( $e = 0$  and  $p = 1$ ).

### 6.8 Symbol Construction

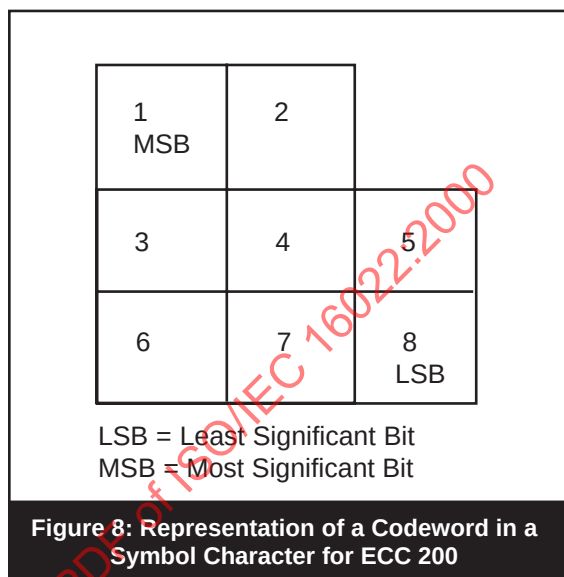
Given the codeword sequence obtained in the previous sections, an ECC 200 symbol is constructed using the following steps:

1. Place codeword modules in a mapping matrix
2. Insert alignment pattern modules, if any
3. Place finder modules along the perimeter

#### 6.8.1 Symbol Character Placement

Each symbol character shall be represented by eight modules which are nominally square in shape; each module represents a binary bit. A dark module is a one and a light module is a zero. The eight modules are in order from left to right and top to bottom to form a symbol character as shown in Figure 8.

Because the symbol character shape defined in Figure 8 cannot be perfectly nested at the symbol boundary, some symbol characters are split into portions. Symbol character placement is defined in the C language program in Annexe M.1, described in Annexe M.2 and illustrated in Annexe M.3.



#### 6.8.2 Alignment Pattern Module Placement

This step is only needed for larger matrices:

- square: 32x32 and larger
- rectangular: 8x32, 12x36 and larger

The mapping matrix is sub-divided into data regions, of the sizes defined in Table 11, for the chosen symbol format. The data regions are separated from each other by two-module-wide alignment patterns. This will result in some of the symbol characters being split between two adjacent data regions.

For square matrices, the alignment patterns are placed between the data regions horizontally and vertically in pairs with a total alignment pattern count of 2, 6, or 10 as shown in Annexe K.1 - K.3. For rectangular matrices, only a single vertical alignment pattern is placed between the data regions as shown in Annexe K.4.

#### 6.8.3 Finder Pattern Module Placement

Modules are placed along the perimeter of the matrix to construct the finder pattern as described in Section 4.3.1.

## 7 Symbol Dimensions

### 7.1 Dimensions

Data Matrix symbols shall conform to the following dimensions:

|                    |                                                                                                                                                               |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X dimension:       | the width of a module shall be specified by the application, taking into account the scanning technology to be used, and the technology to produce the symbol |
| finder pattern:    | the width of the finder pattern shall equal X                                                                                                                 |
| alignment pattern: | the width of the alignment pattern shall equal 2X minimum                                                                                                     |

### 7.2 Quiet zone

The minimum quiet zone is equal to one module width on all four sides.

## 8 Symbol Quality

Data Matrix symbols shall be assessed for quality using the 2D matrix bar code symbol print quality guidelines presented in Annexe N, as augmented and modified below.

### 8.1 Obtaining the Test Image

A grey-scale image of the symbol being tested shall be obtained with a precision video camera-based setup as described in Annexe N.1, but with an illumination color and direction specified by the application.

### 8.2 Symbol Quality Parameters

#### 8.2.1 Decode

The reference decode algorithm presented in Section 9 shall be applied to the test image. If it results in a successful decode of the entire data message, then Decode passes with a grade of "A" (4.0), otherwise it fails with a grade of "F" (0.0).

#### 8.2.2 Symbol Contrast

Symbol contrast shall be graded using all of the grey-scale pixel values in the test image which fall within the symbol's boundary, including the 1X wide quiet zones, as determined by the reference decode.

The procedure is defined in Annexe N.2.2.

#### 8.2.3 "Print" Growth

The reference decode begins by creating a high resolution binary digitized image of the test symbol, and at a later point establishes the position of the "alternating module centerlines" which bisect the alternating patterns on the perimeter of the symbol. "Print" Growth shall be assessed by checking that the "duty cycle" of the lines through the alternating patterns is around 50%.

Taking the top and right side of the symbol independently (since horizontal and vertical growth can differ substantially), proceed from the L-boundary along each perimeter peak line and sum the number of light ( $N_L$ ) and dark ( $N_D$ ) pixels encountered, traversing the full width or height of the symbol but excluding the final dark corner module on ECC 000 - 140 symbols which have an odd number of modules per side. The resulting measure of print growth in each direction is  $D = N_D / (N_L + N_D)$ , which shall be graded against  $D_{NOM} = 0.50$  with  $D_{MIN} = 0.35$  and  $D_{MAX} = 0.65$  as prescribed in Annexe N.2.3. The Print Growth grade shall be the lower of those achieved along the top and right side of the symbol.

#### 8.2.4 Axial Nonuniformity

The reference decode algorithm ultimately creates a grid of data module sampling points throughout the entire data region of the test image. The precise horizontal and vertical spacings of those sampling points are the basis for assessing axial nonuniformity.

Working independently with the horizontal and vertical spacings between adjacent data modules, compute their average values  $X_{AVG}$  and  $Y_{AVG}$  over the whole symbol. The Axial Nonuniformity grade is then based on how closely these two average spacings match each other, as computed by the procedure defined in Annexe N.2.4.

#### 8.2.5 Unused Error Correction

For ECC 000 - ECC 140 versions of Data Matrix, the convolutional error encoding can correct for the following percentages of bit errors:

| Grade  | Reference Decode | Symbol Contrast | "Print" Growth              | Axial Nonuniformity | Unused Error Correction |
|--------|------------------|-----------------|-----------------------------|---------------------|-------------------------|
| A(4.0) | Passes           | $SC \geq 70\%$  | $-0.50 \leq D' \leq 0.50$   | $AN \leq 0.06$      | $UEC \geq 0.62$         |
| B(3.0) |                  | $SC \geq 55\%$  | $-0.70 \leq D' \leq 0.70$   | $AN \leq 0.08$      | $UEC \geq 0.50$         |
| C(2.0) |                  | $SC \geq 40\%$  | $-0.85 \leq D' \leq 0.85$   | $AN \leq 0.10$      | $UEC \geq 0.37$         |
| D(1.0) |                  | $SC \geq 20\%$  | $-1.00 \leq D' \leq 1.00$   | $AN \leq 0.12$      | $UEC \geq 0.25$         |
| F(0.0) | Fails            | $SC < 20\%$     | $D' < -1.00$ or $D' > 1.00$ | $AN > 0.12$         | $UEC < 0.25$            |

**Table 13: Summary of Data Matrix Symbol Print Quality Parameters**

ECC 000:  $E_{MAX} = 0.0\%$   
 ECC 050:  $E_{MAX} = 2.8\%$   
 ECC 080:  $E_{MAX} = 5.5\%$   
 ECC 100:  $E_{MAX} = 12.6\%$   
 ECC 140:  $E_{MAX} = 25.0\%$

Following a successful decode, the actual percentage of bit errors  $E_{ACT}$  is simply the number of bits that were corrected divided by the total number of bits in the symbol's data fields. The Unused Error Correction for these symbols is  $UEC = 1.0 - (E_{ACT} / E_{MAX})$  which is then graded using the table in Annex N.2.5.

The ECC 200 version of Data Matrix employs Reed-Solomon error correction. The smaller symbols contain just a single error correcting block while the larger symbols are subdivided into two or more interleaved blocks. In all cases, each Reed-Solomon block shall be graded independently as specified in Annex N.2.5, then the Unused Error Correction grade shall be the lowest achieved by any of the blocks.

### 8.3 Overall Symbol Grade

The overall print quality grade for a Data Matrix symbol is the lowest of the five grades achieved above. Table 13 summarizes the test criteria.

### 8.4 Process Control Measurements

Several tools and methods are available which can perform useful measurements for monitoring and controlling the process of creating Data Matrix symbols. These include:

1. Symbol contrast readings from a linear bar code verifier.
2. Horizontal print growth from an ECC 200 reference symbol.
3. Determination of axial nonuniformity by

physical measurement

4. Visual inspection of the perimeter pattern for grid nonuniformities and defects.

These tools and methods are described in Annex T.

## 9 Reference Decode Algorithm for Data Matrix

This reference decode algorithm finds the symbols in an image and decodes them. This is the decode algorithm used in the determination of symbol quality. This decode algorithm refers to black and white states in the image. The algorithm is actually applied to the normal image and again with black and white states reversed.

- A. Find the candidate areas which may contain an "L" shaped finder pattern:
  1. Select a global threshold midway between the maximum reflectance and minimum reflectance in the image. Convert the image to black and white using the global threshold.
  2. Define a distance  $d_{min}$  which is the length of the shortest expected leg of an imaged symbol's "L" finder pattern ( $d_{min}$  will depend on the pixel density, camera focal length, maximum reading distance, and minimum X-dimension.)
  3. Find all the areas with closed continuous boundaries of white on the outside and black on the inside. Note that one candidate area may be totally contained within another candidate area.
  4. Disregard all areas which have a longest axis less than  $0.5 d_{min}$ .
  5. Form new merged candidate areas by merging any adjacent areas with a small

separation:

- a. If two areas are separated by less than  $0.15 d_{\min}$ , form a new area by joining the two areas across the minimum separation point.
  - b. Keep the two adjacent areas and the merged area as three candidate areas.
  - c. Repeat the merging process to form new unique merged areas from all original and merged area combinations.
6. Form new divided candidate areas from any candidate areas with a narrow neck separating large sub-areas, ignoring the merged areas from the previous step:
    - a. If an area contains a neck less than  $0.15 d_{\min}$  wide at its narrowest and separates two sub-areas each with a longest axis of at least  $d_{\min}$ , create two new candidate areas by breaking the original area into two new areas across the narrowest part of the neck.
    - b. Keep the original larger area and the two new divided areas as three candidate areas.
    - c. Repeat the dividing process to form new divided areas from all original and divided areas.
  7. Ignore any area with a longest axis less than  $d_{\min}$ . The remaining candidate areas will be processed in the following steps to try to decode valid symbols.
- B. Find the “L” shaped finder pattern in a candidate area:
1. Sort the points in the area’s boundary into sets that fall along straight lines, within 3% of the longest axis of the candidate area. For each set of points, plot a line which minimizes the sum of distances between each of the points in the set and the closest point on the line.
  2. Select the line with the most points. Select a second line with the most number of points which is also perpendicular to the first line to within 10 degrees. If the second line does not contain at least 20% of the number of points in the first line, disregard the area.
  3. The two lines may form the outline of two sides of the “L” in a symbol’s finder pattern.
- C. Find two new lines which are a weighted best fit to the outside of the “L” in the area around the corner of the “L”:
1. Plot the intersection of the two lines. For each of the two sets of points, calculate the weights for each of the distances from the points to the line as follows.
  2. Divide the distance from the farthest point in the set and the intersection of the two “L” lines by  $d_{\min}$ . Discard the remainder. Call the quotient N.
  3. Divide the set of points into N subsets in sequence starting from the point closest to the intersection of the two lines and ending with the farthest point.
  4. Weight the point-to-line distances for the subset of points closest to the intersection by weight N, the next subset’s distances by N-1, ..., and the farthest subset’s distances by one.
  5. For each side, find a new line which minimizes the sum of the weighted distances between the new line and the side’s set of points.
- D. First assume that the candidate area contains a square symbol. If the area fails to decode as a square symbol, then try to find and decode a rectangular symbol starting from procedure J. For a square symbol, first plot a normalized graph of transitions for the equal sides of the candidate area in order to find the alternating module finder pattern:
1. Project a line through the candidate area bisecting the interior angle of the two sides of the “L” found in step C.5 as shown in Figure 9. Define the two equal areas formed by the bisecting line as the right side and left side as viewed from the corner of the “L”.
  2. For each side, form a line called a “search line” between a point  $d_{\min}$  distance from the corner along the “L” line, parallel to the other “L” side line, and extending to the bisecting line as shown in Figure 9.
  3. Move each search line away from the corner of the “L” as shown in Figure 9, lengthening each line as it expands to span its two bounding lines, the “L” line and the bisecting line. Keep each search line parallel to the other “L” side line. As each side is moved by an image pixel, plot the sum of number of black/white and white/black transitions multiplied by the length of the longest “L”

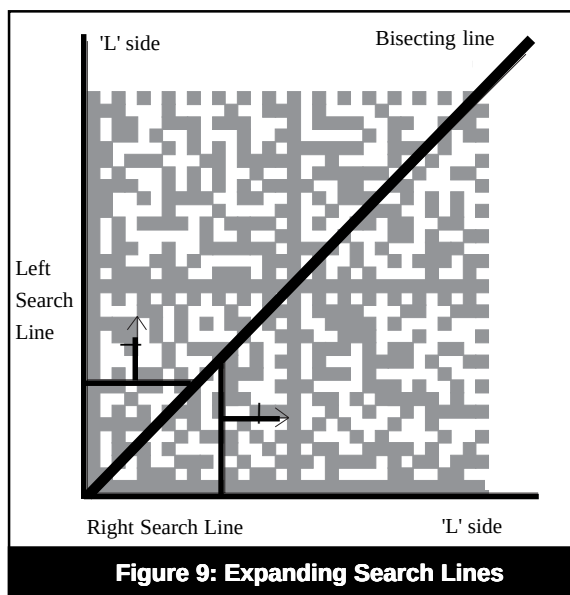


**Figure 9: Expanding Search Lines**

side divided by the current length of the search line measured between the two bounding lines:

$$T = (\text{number of transitions}) \times (\text{"L" max line length}) / (\text{search line length}).$$

This formula normalizes T to keep it from increasing because the line lengthens. Continue to calculate the T values until the search line is longer than the longest axis of the candidate area plus 50%.

4. Form a plot of the T values for each side, where the Y axis is the T value and the X axis is the search line's distance from the corner of the "L". A sample plot is shown in Figure 10.
5. Starting from the T value with the smallest X in the right side's plot and then increasing X, find the first instance of a descending line where the T value at the valley is less than 15% of the peak's value. If the peak or valley in the plot has a flat plateau or floor, select the peak or valley point closest to the descending line in the plot. The search line at the peak may correspond to an alternating finder pattern side. At the valley, the search line may correspond to the solid dark interior line or a light quiet zone.

6. Find a peak and valley in the left side's plot which most nearly matches the right peak and valley X values. If either of the selected left side peak or valley X values differ by more than 15% from the equivalent right side peak or valley X values, discard the right side peak and valley and continue searching from step D.5 for the next peak and valley. The 15% specifies the maximum allowed foreshortening.
7. The right side's valley search line, the left side's valley search line, and the two sides of the "L" outline a possible symbol's data region. Process the data region according to step E. If the decode fails, discard the right side peak and valley and continue searching from step D.5 for the next peak and valley.

- E. For each of the two sides of the alternating pattern, find the line passing through the center of the alternating light and dark modules:
  1. For each side, form a rectangular region bounded by the side's peak and valley search lines as the longer two sides of the rectangle, and the "L" side and the other side's valley search line as the shorter two sides, as shown in Figure 11.
  2. In each rectangular region, sort the black/white boundary points into sets which fit a straight line as in step B.1. Select the set with the most points and find the minimum distance line as in step B.1. This line should pass along the outside of the alternating pattern, shown as the "best fit line" in Figure 12.
  3. For each side, construct a line parallel to the step E.2 line which is offset toward the "L" corner by the length of the peak search line divided by twice the number of transitions in the peak search line:

$$\text{Offset} = \text{length of peak line} / (\text{number of transitions} \times 2)$$

Each of the two constructed lines should correspond to the center-line or midline of the alternating module pattern on that side, see Figure 13.

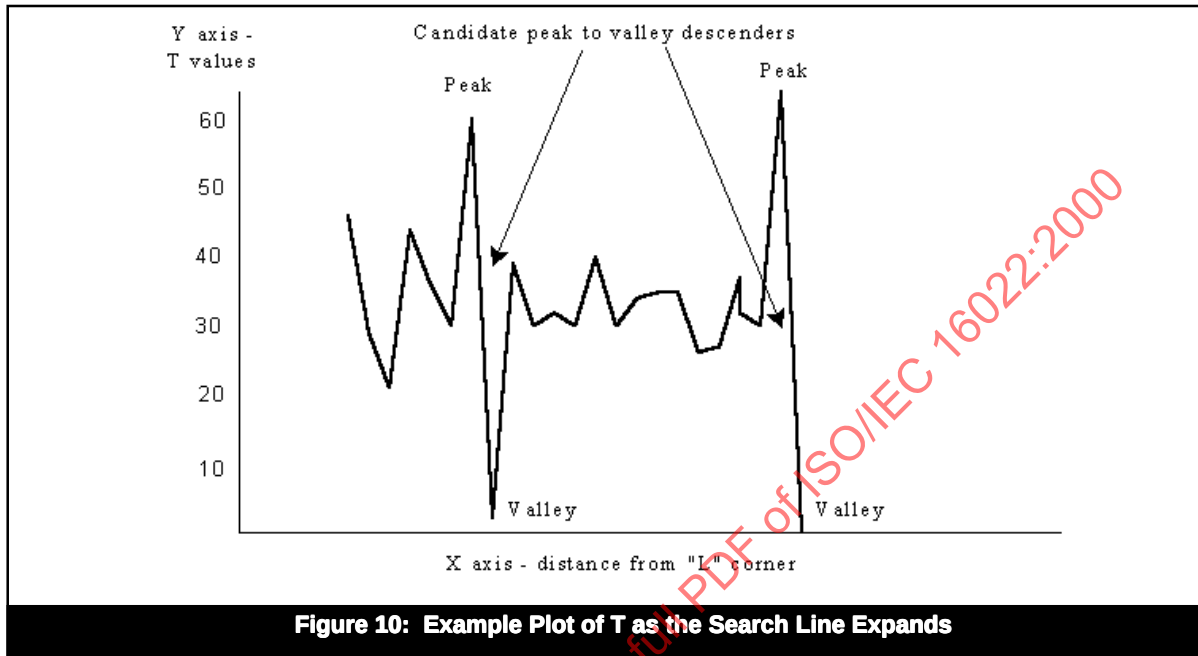


Figure 10: Example Plot of T as the Search Line Expands

- F. For each side, determine the number of data modules in the side of the square symbol or data region:
1. Bound the alternating pattern mid-line constructed in step E.3 by the adjacent "L" line and the other alternating pattern mid-line from step E.3. Call the length of this line  $M_d$  (see Figure 11).
  2. Along each bounded mid-line, measure the edge-to-edge distances between all the similar edges (note that this will include measurements across all adjacent sets of 2, 4, 6, ... modules).
  3. Sort the edge-to-edge measurements into sets where the edge-to-edge distances within each set differ by less than plus or minus 25% from the geometric mean of the set's two extremes.
  4. Calculate the average of the largest set of distances for the side. Call the average  $E_{avg}$ .
  5. The calculated number of data modules "dm" is defined by the formula:  

$$dm = ((M_d * 2) / E_{avg}) - 1.5$$
 where "dm" is rounded to the nearest integer value.
  6. If the number of edge-to-edge measurements in the set is greater than "dm", delete the excess number from the edge-to-edge measurements found in step F.2 which differ most from  $E_{avg}$ . Recalculate  $E_{avg}$  and a new "dm" according to steps F.4 and F.5 using the remaining edge-to-edge measurements in the set. This should remove any spurious short and long edge-to-edge measurements caused by spots and voids.
  7. If "dm" differs for the two sides, discard the right side peak and valley and continue searching from step D.5 for the next peak and valley. Otherwise, dm is the size of the square data region.
- G. For each side, find the center points of the alternating pattern modules:
1. Divide the  $M_d$  by the sum of "dm" and 1.5 to form the module pitch:  

$$\text{Module pitch} = M_d / (dm + 1.5).$$
  2. Calculate "dm" module centers along the step E.3 line with the first being 1.5 times the module pitch from the "L" side and each successive center spaced one module pitch further along the step E.3 line.
- H. Plot the data module sampling grid in the data region by extending the alternating pattern

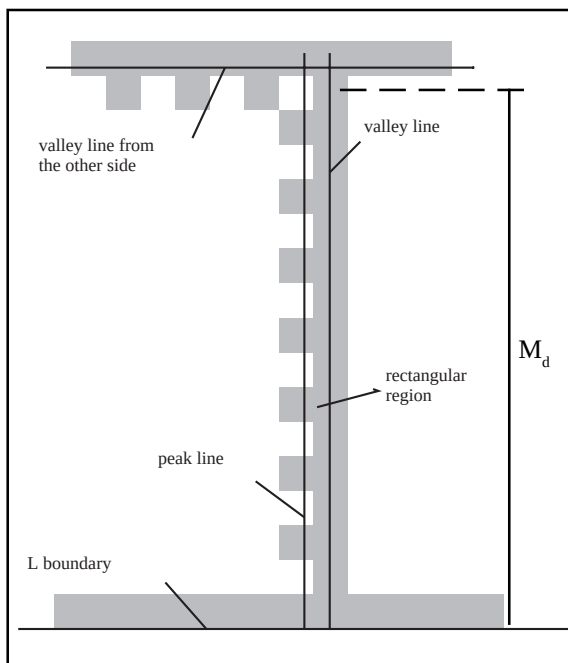


Figure 11: Rectangular Region Construction

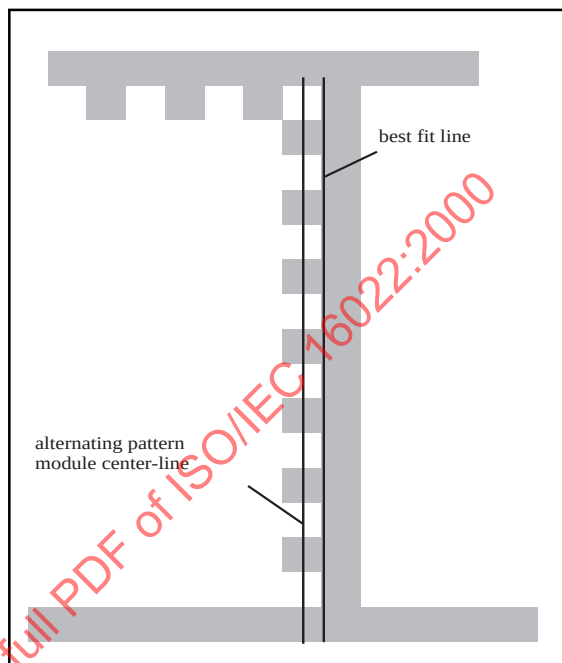


Figure 12: Alternating Module Center-line

module centers:

1. Extend each side's step E.3 midline and the opposite side's "L" line to form the vanishing point of the two nearly parallel or parallel extended lines.
  2. Extend rays from each vanishing point passing through the step G module centers of the nearly perpendicular step E.3 line.
  3. The intersection of the two sets of nearly perpendicular rays should correspond to the centers of the data modules in the data region, as shown in Figure 13.
- I. Continue to fill in the remaining data regions.
1. When a data region is processed, form a new "L" for the next data section to the "left" or "above" using one of two processes:
    - a. If the new data region is still bounded on one side by the original "L" from procedure B, repeat from procedure C to process the new data region using the selected set of points from step E.2 and the set of points on the "L" from step B.2 which lie beyond the step E.2 line.
    - b. If the new data region is bounded on two sides by data regions, repeat from

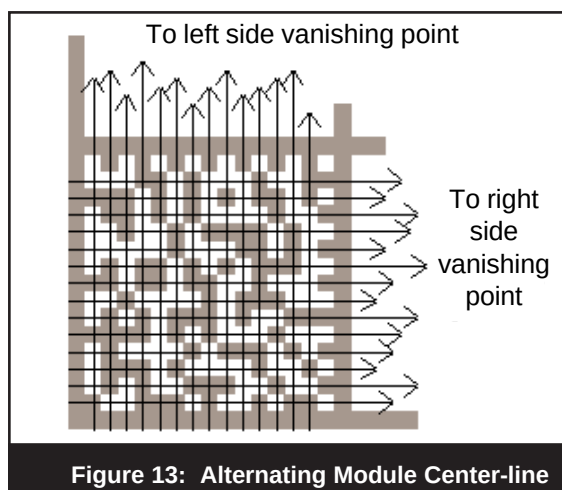


Figure 13: Alternating Module Center-line

procedure C to process the new data region using the selected set of points from step E.2 for each data region which are adjacent and bound the new region on two sides

2. If a data region does not match the number of modules in previously processed regions trim the symbol to the largest number of regions which correspond to a legal symbol.

3. Decode the symbol with its one or more data regions starting with procedure K.
- J. Find the data sections of a rectangular symbol.
1. For each side of the “L” move a line perpendicular to the side and scanning along the length of the other side of the “L”. As each side is moved by a pixel, plot the sum of number of black/white and white/black transitions:
$$T = (\text{number of transitions}) \times (\text{“L” max line length}) / (\text{search line length}).$$

Continue until the parallel line moves further than the perpendicular leg of the “L” plus 10%.

  - 2. Starting from the origin of the plot, for each direction, find the first instance of a descending line where the T value at the valley is less than 15% of the peak’s value. If the peak or valley in the plot has a flat plateau or floor, select the peak or valley point closest to the descending line in the plot. The valley line at this point may form a side of a symbol or data region.
  - 3. Find the alternating pattern lines for each side of the region similar to procedure E.
  - 4. Plot the module sample grid in the data region or symbol as in procedures F, G, and H. Skip step F.6 which requires that the region is square.
  - 5. If the data region defined is not a valid rectangular symbol, try to form a new data region using further valid peak to valley plot transitions.
  - 6. Process any additional regions as in procedure I.
  - 7. If a valid data region or two regions are detected, attempt to decode the symbol as in procedures K and L. If the region(s) were not valid or the decode fails, disregard the candidate area.
- K. If the number of data modules is even or the symbol forms a valid rectangular symbol, decode the symbol using Reed-Solomon error correction:
1. Sample the data modules at their predicted centers. Black at the center is a one and white is a zero.
  2. Convert the eight module samples in the defined codeword patterns into 8-bit symbol character values.
  3. Apply Reed-Solomon error correction to the symbol character values.
  4. Decode the symbol characters into data characters according to the specified encodation schemes.
- L. Otherwise the number of data modules is odd, so decode the symbol using convolution code error correction:
1. Sample the data modules at their predicted centers. Black at the center is a one and white is a zero.
  2. Apply the black/white balancing mask.
  3. Use the bit ordering table to convert the data into a bit stream.
  4. Apply the appropriate convolution code error correction.
  5. Convert the bit stream to data characters according to the encodation scheme specified.
  6. Verify that the CRC is correct.
- M. If a successful decode has not resulted, after all of the candidate regions have been processed, reverse the black and white states and reapply the entire algorithm to the reversed image.

## 10 User Guidelines

### 10.1 Human Readable Interpretation

Because Data Matrix symbols are capable of encoding thousands of characters, a human readable interpretation of the data characters may not be practical. As an alternative, descriptive text rather than the encoded text may accompany the symbol. The character size and font are not specified, and the message may be printed anywhere in the area surrounding the symbol. The human readable interpretation should not interfere with the symbol itself nor the quiet zones.

### 10.2 Autodiscrimination Capability

Data Matrix can be used in an autodiscrimination environment with a number of other symbologies. (See Annexe U).

### 10.3 System Consideration

Data Matrix application must be viewed as a total system solution (see Annexe V).

## 11 Transmitted Data

This section describes the standard transmission protocol for compliant readers. These readers may be programmable to support other transmission options.

All encoded data characters are included in the data transmission. The symbology control characters and error correction characters are not transmitted. More complex interpretations are addressed below.

### 11.1 Protocol for FNC1 (ECC 200 Only)

When FNC1 appears in the first symbol character position (or in the fifth symbol character position of the first symbol of a Structured Append), it shall signal that the data conforms to the UCC/EAN Application Identifier standard format. FNC1 in any other later position acts as a field separator. Transmission of symbology identifiers shall be enabled. The first FNC1 shall not be represented in the transmitted data, although its presence is indicated by the use of the appropriate option value (2) in the symbology identifier (see Section 11.5). When used as a field separator, FNC1 shall be represented in the transmitted message by the ASCII character <GS> (ASCII value 29).

### 11.2 Protocol for FNC1 in the Second Position

When FNC1 is in the second symbol character position (or in the sixth symbol character position of the first symbol of a Structured Append), it shall signal that the data conform to a particular industry standard format.

Transmission of symbology identifiers shall be enabled. The first FNC1 shall not be represented in the transmitted data, although its presence is indicated by the use of the appropriate option value (3) in the symbology identifier (see Section 11.5). The data encoded in the first symbol character shall be transmitted as normal at the beginning of the data. When used as a field separator, FNC1 shall be represented in the transmitted message by the ASCII character <GS> (ASCII value 29).

### 11.3 Protocol for Macro Characters in the First Position (ECC 200 only)

This protocol is used to encode two specific message headers and trailers in an abbreviated manner in ECC 200 symbols.

When a Macro character is in the first position a preamble and postamble shall be transmitted. If the first symbol character is 236 (i.e. encoding Macro 05), then the preamble  $[ ] >^R_5 05^G_S$  shall precede the encoded data that follows it. If the first symbol character is 237 (i.e. encoding Macro 06), then the preamble  $[ ] >^R_5 06^G_S$  shall precede the encoded data that follows it. The postamble  $^R_5 E_{OT}$  shall be transmitted after the data in both cases.

### 11.4 Protocol for ECIs (ECC 200 Only)

In systems where ECIs are supported, the use of a symbology identifier prefix is required with every transmission. Whenever an ECI codeword is encountered, it shall be transmitted as the escape character  $92_{DEC}$  (or  $5C_{HEX}$ ), which represents the character “\” (backslash or reverse solidus) in the default interpretation. The next codeword(s) are converted into a 6-digit value, inverting the rules defined in Table 10. The 6-digit value is transmitted as the appropriate ASCII values (48-57).

Application software recognizing \nnnnnn should interpret all subsequent characters as being from the ECI defined by the 6-digit sequence. This interpretation remains in effect until the end of the encoded data or until another ECI sequence is encountered.

If the backslash (byte  $92_{DEC}$ ) needs to be used as encoded data, transmission shall be as follows. Whenever (ASCII  $92_{DEC}$ ) occurs as data, two bytes of that value shall be transmitted, thus a single occurrence is always an escape character and a double occurrence indicates true data.

#### Example:

Encoded data: A\\B\C

Transmission: A\\B\C

Use of the symbology identifier assures that the application can correctly interpret the escape character.

### 11.5 Symbology Identifier

EN796 provides a standard procedure for reporting the symbology which has been read, together with options set in the decoder and special features encountered in the symbol.

Once the structure of the data (including the use of any ECI) has been identified, the appropriate symbology identifier should be added by the decoder as a preamble to the transmitted data. The symbology identifier is required if ECIs appear anywhere in the symbol, or if FNC1 is used as defined in 11.1 or 11.2. See Annex P for the symbology identifier and option values which apply to Data Matrix.

### 11.6 Transmitted Data Example

In this example, the two-character message “¶ Ж” is to be encoded in ECC 200, using the ASCII encodation scheme. “¶” is represented by a byte value of 182 in Data Matrix's default character set (ECI 000003, which is equivalent to ISO 8859-1). “Ж” is a Cyrillic character not available in ECI 000003, but which can be represented in ISO 8859-5 (ECI 000007) by the same byte value of 182. The complete message can therefore be represented by inserting a switch to ECI 000007 after the first character, as follows:

The symbol encodes the message <¶> <Switch to ECI 000007> <Ж> using the following series of Data Matrix codewords (note that an Upper Shift character, followed by a codeword of value 55, encodes a byte value of 182; further note that ECIs are encoded in Data Matrix as the ECI number plus one):

[Upper Shift] [55] [ECI] [8] [Upper Shift] [55],  
with decimal values of  
[235], [55], [241], [8], [235], [55].

The decoder transmits the following bytes (including the symbology identifier prefix with an option value of 4, which indicates use of the ECI protocol):

93, 100, 52, 182, 92, 48, 48, 48, 48, 48, 55, 182  
which, if viewed entirely in the default  
interpretation, would appear graphically as:

]d4¶\000007¶

Note that the decoder is responsible for signalling the switch to ECI 000007, but not for interpreting

the result.

ECI-aware software in the receiving application would delete the ECI escape sequence \000007, and the Cyrillic character “Ж” would be represented in a system-dependent manner (eg, by changing the font in a desktop-publishing file). The final result would match the original message of “¶ Ж”.

## Annexe A (Normative)

### ECC 000 - 140 Symbol Attributes

#### A.1 ECC 000

| Symbol Size* |     | Data Region Size |     | Numeric Capacity | Alphanum Capacity | 8-bit byte Capacity | Error Correction Overhead % | % Correctable |
|--------------|-----|------------------|-----|------------------|-------------------|---------------------|-----------------------------|---------------|
| Row          | Col | Row              | Col |                  |                   |                     |                             |               |
| 9            | 9   | 7                | 7   | 3                | 2                 | 1                   | 0.0                         | 0.0           |
| 11           | 11  | 9                | 9   | 12               | 8                 | 5                   | 0.0                         | 0.0           |
| 13           | 13  | 11               | 11  | 24               | 16                | 10                  | 0.0                         | 0.0           |
| 15           | 15  | 13               | 13  | 37               | 25                | 16                  | 0.0                         | 0.0           |
| 17           | 17  | 15               | 15  | 53               | 35                | 23                  | 0.0                         | 0.0           |
| 19           | 19  | 17               | 17  | 72               | 48                | 31                  | 0.0                         | 0.0           |
| 21           | 21  | 19               | 19  | 92               | 61                | 40                  | 0.0                         | 0.0           |
| 23           | 23  | 21               | 21  | 115              | 76                | 50                  | 0.0                         | 0.0           |
| 25           | 25  | 23               | 23  | 140              | 93                | 61                  | 0.0                         | 0.0           |
| 27           | 27  | 25               | 25  | 168              | 112               | 73                  | 0.0                         | 0.0           |
| 29           | 29  | 27               | 27  | 197              | 131               | 86                  | 0.0                         | 0.0           |
| 31           | 31  | 29               | 29  | 229              | 153               | 100                 | 0.0                         | 0.0           |
| 33           | 33  | 31               | 31  | 264              | 176               | 115                 | 0.0                         | 0.0           |
| 35           | 35  | 33               | 33  | 300              | 200               | 131                 | 0.0                         | 0.0           |
| 37           | 37  | 35               | 35  | 339              | 226               | 148                 | 0.0                         | 0.0           |
| 39           | 39  | 37               | 37  | 380              | 253               | 166                 | 0.0                         | 0.0           |
| 41           | 41  | 39               | 39  | 424              | 282               | 185                 | 0.0                         | 0.0           |
| 43           | 43  | 41               | 41  | 469              | 313               | 205                 | 0.0                         | 0.0           |
| 45           | 45  | 43               | 43  | 500              | 345               | 226                 | 0.0                         | 0.0           |
| 47           | 47  | 45               | 45  | 560              | 378               | 248                 | 0.0                         | 0.0           |
| 49           | 49  | 47               | 47  | 596              | 413               | 271                 | 0.0                         | 0.0           |

#### A.2 ECC 050

| Symbol Size* |     | Data Region Size |     | Numeric Capacity | Alphanum Capacity | 8-bit byte Capacity | Error Correction Overhead % | % Correctable |
|--------------|-----|------------------|-----|------------------|-------------------|---------------------|-----------------------------|---------------|
| Row          | Col | Row              | Col |                  |                   |                     |                             |               |
| 11           | 11  | 9                | 9   | 1                | 1                 | **                  | 25.0                        | 2.8           |
| 13           | 13  | 11               | 11  | 10               | 6                 | 4                   | 25.0                        | 2.8           |
| 15           | 15  | 13               | 13  | 20               | 13                | 9                   | 25.0                        | 2.8           |
| 17           | 17  | 15               | 15  | 32               | 21                | 14                  | 25.0                        | 2.8           |
| 19           | 19  | 17               | 17  | 46               | 30                | 20                  | 25.0                        | 2.8           |
| 21           | 21  | 19               | 19  | 61               | 41                | 27                  | 25.0                        | 2.8           |
| 23           | 23  | 21               | 21  | 78               | 52                | 34                  | 25.0                        | 2.8           |
| 25           | 25  | 23               | 23  | 97               | 65                | 42                  | 25.0                        | 2.8           |
| 27           | 27  | 25               | 25  | 118              | 78                | 51                  | 25.0                        | 2.8           |
| 29           | 29  | 27               | 27  | 140              | 93                | 61                  | 25.0                        | 2.8           |
| 31           | 31  | 29               | 29  | 164              | 109               | 72                  | 25.0                        | 2.8           |
| 33           | 33  | 31               | 31  | 190              | 126               | 83                  | 25.0                        | 2.8           |
| 35           | 35  | 33               | 33  | 217              | 145               | 95                  | 25.0                        | 2.8           |
| 37           | 37  | 35               | 35  | 246              | 164               | 108                 | 25.0                        | 2.8           |
| 39           | 39  | 37               | 37  | 277              | 185               | 121                 | 25.0                        | 2.8           |
| 41           | 41  | 39               | 39  | 310              | 206               | 135                 | 25.0                        | 2.8           |
| 43           | 43  | 41               | 41  | 344              | 229               | 150                 | 25.0                        | 2.8           |
| 45           | 45  | 43               | 43  | 380              | 253               | 166                 | 25.0                        | 2.8           |
| 47           | 47  | 45               | 45  | 418              | 278               | 183                 | 25.0                        | 2.8           |
| 49           | 49  | 47               | 47  | 457              | 305               | 200                 | 25.0                        | 2.8           |

\* Excluding quiet zone

\*\*Note: This combination is not possible

## A.3 ECC 080

| Symbol Row | Size* Col | Data Row | Region Col | Size | Numeric Capacity | Alphanum Capacity | 8-bit byte Capacity | Error Correction Overhead % | % Correctable |
|------------|-----------|----------|------------|------|------------------|-------------------|---------------------|-----------------------------|---------------|
| 13         | 13        | 11       | 11         |      | 4                | 3                 | 2                   | 33.3                        | 5.5           |
| 15         | 15        | 13       | 13         |      | 13               | 9                 | 6                   | 33.3                        | 5.5           |
| 17         | 17        | 15       | 15         |      | 24               | 16                | 10                  | 33.3                        | 5.5           |
| 19         | 19        | 17       | 17         |      | 36               | 24                | 16                  | 33.3                        | 5.5           |
| 21         | 21        | 19       | 19         |      | 50               | 33                | 22                  | 33.3                        | 5.5           |
| 23         | 23        | 21       | 21         |      | 65               | 43                | 28                  | 33.3                        | 5.5           |
| 25         | 25        | 23       | 23         |      | 82               | 54                | 36                  | 33.3                        | 5.5           |
| 27         | 27        | 25       | 25         |      | 100              | 67                | 44                  | 33.3                        | 5.5           |
| 29         | 29        | 27       | 27         |      | 120              | 80                | 52                  | 33.3                        | 5.5           |
| 31         | 31        | 29       | 29         |      | 141              | 94                | 62                  | 33.3                        | 5.5           |
| 33         | 33        | 31       | 31         |      | 164              | 109               | 72                  | 33.3                        | 5.5           |
| 35         | 35        | 33       | 33         |      | 188              | 125               | 82                  | 33.3                        | 5.5           |
| 37         | 37        | 35       | 35         |      | 214              | 143               | 94                  | 33.3                        | 5.5           |
| 39         | 39        | 37       | 37         |      | 242              | 161               | 106                 | 33.3                        | 5.5           |
| 41         | 41        | 39       | 39         |      | 270              | 180               | 118                 | 33.3                        | 5.5           |
| 43         | 43        | 41       | 41         |      | 301              | 201               | 132                 | 33.3                        | 5.5           |
| 45         | 45        | 43       | 43         |      | 333              | 222               | 146                 | 33.3                        | 5.5           |
| 47         | 47        | 45       | 45         |      | 366              | 244               | 160                 | 33.3                        | 5.5           |
| 49         | 49        | 47       | 47         |      | 402              | 268               | 176                 | 33.3                        | 5.5           |

## A.4 ECC 100

| Symbol Row | Size* Col | Data Row | Region Col | Size | Numeric Capacity | Alphanum Capacity | 8-bit byte Capacity | Error Correction Overhead % | % Correctable |
|------------|-----------|----------|------------|------|------------------|-------------------|---------------------|-----------------------------|---------------|
| 13         | 13        | 11       | 11         |      | 1                | 1                 | **                  | 50.0                        | 12.6          |
| 15         | 15        | 13       | 13         |      | 8                | 5                 | 3                   | 50.0                        | 12.6          |
| 17         | 17        | 15       | 15         |      | 16               | 11                | 7                   | 50.0                        | 12.6          |
| 19         | 19        | 17       | 17         |      | 25               | 17                | 11                  | 50.0                        | 12.6          |
| 21         | 21        | 19       | 19         |      | 36               | 24                | 15                  | 50.0                        | 12.6          |
| 23         | 23        | 21       | 21         |      | 47               | 31                | 20                  | 50.0                        | 12.6          |
| 25         | 25        | 23       | 23         |      | 60               | 40                | 26                  | 50.0                        | 12.6          |
| 27         | 27        | 25       | 25         |      | 73               | 49                | 32                  | 50.0                        | 12.6          |
| 29         | 29        | 27       | 27         |      | 88               | 59                | 38                  | 50.0                        | 12.6          |
| 31         | 31        | 29       | 29         |      | 104              | 69                | 45                  | 50.0                        | 12.6          |
| 33         | 33        | 31       | 31         |      | 121              | 81                | 53                  | 50.0                        | 12.6          |
| 35         | 35        | 33       | 33         |      | 140              | 93                | 61                  | 50.0                        | 12.6          |
| 37         | 37        | 35       | 35         |      | 159              | 106               | 69                  | 50.0                        | 12.6          |
| 39         | 39        | 37       | 37         |      | 180              | 120               | 78                  | 50.0                        | 12.6          |
| 41         | 41        | 39       | 39         |      | 201              | 134               | 88                  | 50.0                        | 12.6          |
| 43         | 43        | 41       | 41         |      | 224              | 149               | 98                  | 50.0                        | 12.6          |
| 45         | 45        | 43       | 43         |      | 248              | 165               | 108                 | 50.0                        | 12.6          |
| 47         | 47        | 45       | 45         |      | 273              | 182               | 119                 | 50.0                        | 12.6          |
| 49         | 49        | 47       | 47         |      | 300              | 200               | 131                 | 50.0                        | 12.6          |

\* Excluding quiet zone

\*\*Note: This combination is not possible

## A.5 ECC 140

| Symbol Size* |     | Data Region Size |     | Numeric Capacity | Alphanum Capacity | 8-bit byte Capacity | Error Correction Overhead % | % Correctable |
|--------------|-----|------------------|-----|------------------|-------------------|---------------------|-----------------------------|---------------|
| Row          | Col | Row              | Col |                  |                   |                     |                             |               |
| 17           | 17  | 15               | 15  | 2                | 1                 | 1                   | 75.0                        | 25.0          |
| 19           | 19  | 17               | 17  | 6                | 4                 | 3                   | 75.0                        | 25.0          |
| 21           | 21  | 19               | 19  | 12               | 8                 | 5                   | 75.0                        | 25.0          |
| 23           | 23  | 21               | 21  | 17               | 11                | 7                   | 75.0                        | 25.0          |
| 25           | 25  | 23               | 23  | 24               | 16                | 10                  | 75.0                        | 25.0          |
| 27           | 27  | 25               | 25  | 30               | 20                | 13                  | 75.0                        | 25.0          |
| 29           | 29  | 27               | 27  | 38               | 25                | 16                  | 75.0                        | 25.0          |
| 31           | 31  | 29               | 29  | 46               | 30                | 20                  | 75.0                        | 25.0          |
| 33           | 33  | 31               | 31  | 54               | 36                | 24                  | 75.0                        | 25.0          |
| 35           | 35  | 33               | 33  | 64               | 42                | 28                  | 75.0                        | 25.0          |
| 37           | 37  | 35               | 35  | 73               | 49                | 32                  | 75.0                        | 25.0          |
| 39           | 39  | 37               | 37  | 84               | 56                | 36                  | 75.0                        | 25.0          |
| 41           | 41  | 39               | 39  | 94               | 63                | 41                  | 75.0                        | 25.0          |
| 43           | 43  | 41               | 41  | 106              | 70                | 46                  | 75.0                        | 25.0          |
| 45           | 45  | 43               | 43  | 118              | 78                | 51                  | 75.0                        | 25.0          |
| 47           | 47  | 45               | 45  | 130              | 87                | 57                  | 75.0                        | 25.0          |
| 49           | 49  | 47               | 47  | 144              | 96                | 63                  | 75.0                        | 25.0          |

\* Excluding quiet zone

*Annexe B (Normative) These tables are available in electronic format  
ECC 000 - 140 Data Module Placement Grids*

NOTE: module position 0 is the MSB of the randomized bit stream

7x7 data:

```

2 45 10 38 24 21 1
12 40 26 5 33 19 47
22 31 29 15 43 8 36
34 20 48 13 41 27 6
44 9 37 23 17 30 16
39 25 4 32 18 46 11
0 28 14 42 7 35 3

```

9x9 data:

```

2 19 55 10 46 28 64 73 1
62 17 53 35 71 8 80 44 26
49 31 67 4 76 40 22 58 13
69 6 78 42 24 60 15 51 33
74 38 20 56 11 47 29 65 37
25 61 16 52 34 70 7 79 43
12 48 30 66 63 75 39 21 57
32 68 5 77 41 23 59 14 50
0 72 36 18 54 9 45 27 3

```

11x11 data:

```

2 26 114 70 15 103 59 37 81 4 1
117 73 18 106 62 40 84 7 95 51 29
12 100 56 34 78 92 89 45 23 111 67
65 43 87 10 98 54 32 120 76 21 109
82 5 93 49 27 115 71 16 104 60 38
96 52 30 118 74 19 107 63 41 85 8
24 112 68 13 101 57 35 79 48 90 46
75 20 108 64 42 86 9 97 53 31 119
102 58 36 80 77 91 47 25 113 69 14
39 83 6 94 50 28 116 72 17 105 61
0 88 44 22 110 66 11 99 55 33 3

```

13x13 data:

```

2 159 29 133 81 16 120 68 42 146 94 91 1
37 141 89 24 128 76 50 154 102 11 115 63 167
83 18 122 70 44 148 96 5 109 57 161 31 135
125 73 47 151 99 8 112 60 164 34 138 86 21
40 144 92 107 105 53 157 27 131 79 14 118 66
103 12 116 64 168 38 142 90 25 129 77 51 155
110 58 162 32 136 84 19 123 71 45 149 97 6
165 35 139 87 22 126 74 48 152 100 9 113 61
132 80 15 119 67 41 145 93 55 106 54 158 28
23 127 75 49 153 101 10 114 62 166 36 140 88
69 43 147 95 4 108 56 160 30 134 82 17 121
150 98 7 111 59 163 33 137 85 20 124 72 46
0 104 52 156 26 130 78 13 117 65 39 143 3

```

15x15 data:

```

2 187 37 157 97 217 22 142 82 202 52 172 112 7 1
41 161 101 221 26 146 86 206 56 176 116 11 131 71 191
93 213 18 138 78 198 48 168 108 105 123 63 183 33 153
28 148 88 208 58 178 118 13 133 73 193 43 163 103 223
80 200 50 170 110 5 125 65 185 35 155 95 215 20 140
54 174 114 9 129 69 189 39 159 99 219 24 144 84 204
106 127 121 61 181 31 151 91 211 16 136 76 196 46 166
134 74 194 44 164 104 224 29 149 89 209 59 179 119 14
186 36 156 96 216 21 141 81 201 51 171 111 6 126 66
160 100 220 25 145 85 205 55 175 115 10 130 70 190 40
212 17 137 77 197 47 167 107 67 122 62 182 32 152 92
147 87 207 57 177 117 12 132 72 192 42 162 102 222 27
199 49 169 109 4 124 64 184 34 154 94 214 19 139 79
173 113 8 128 68 188 38 158 98 218 23 143 83 203 53
0 120 60 180 30 150 90 210 15 135 75 195 45 165 3

```

## 17x17 data:

```

2 69 205 35 171 103 239 18 154 86 222 52 188 120 256 273 1
220 50 186 118 254 33 169 101 237 67 203 135 271 16 288 152 84
178 110 246 25 161 93 229 59 195 127 263 8 280 144 76 212 42
250 29 165 97 233 63 199 131 267 12 284 148 80 216 46 182 114
157 89 225 55 191 123 259 4 276 140 72 208 38 174 106 242 21
235 65 201 133 269 14 286 150 82 218 48 184 116 252 31 167 99
193 125 261 6 278 142 74 210 40 176 108 244 23 159 91 227 57
265 10 282 146 78 214 44 180 112 248 27 163 95 231 61 197 129
274 138 70 206 36 172 104 240 19 155 87 223 53 189 121 257 137
83 219 49 185 117 253 32 168 100 236 66 202 134 270 15 287 151
41 177 109 245 24 160 92 228 58 194 126 262 7 279 143 75 211
113 249 28 164 96 232 62 198 130 266 11 283 147 79 215 45 181
20 156 88 224 54 190 122 258 255 275 139 71 207 37 173 105 241
98 234 64 200 132 268 13 285 149 81 217 47 183 115 251 30 166
56 192 124 260 5 277 141 73 209 39 175 107 243 22 158 90 226
128 264 9 281 145 77 213 43 179 111 247 26 162 94 230 60 196
0 272 136 68 204 34 170 102 238 17 153 85 221 51 187 119 3

```

## 19x19 data:

```

2 82 234 44 348 196 120 272 25 329 177 101 253 63 215 139 291 6 1
239 49 353 201 125 277 30 334 182 106 258 68 220 144 296 11 315 163 87
343 191 115 267 20 324 172 96 248 58 210 134 286 310 305 153 77 229 39
132 284 37 341 189 113 265 75 227 151 303 18 322 170 94 246 56 360 208
28 332 180 104 256 66 218 142 294 9 313 161 85 237 47 351 199 123 275
185 109 261 71 223 147 299 14 318 166 90 242 52 356 204 128 280 33 337
251 61 213 137 289 4 308 156 80 232 42 346 194 118 270 23 327 175 99
225 149 301 16 320 168 92 244 54 358 206 130 282 35 339 187 111 263 73
292 7 311 159 83 235 45 349 197 121 273 26 330 178 102 254 64 216 140
316 164 88 240 50 354 202 126 278 31 335 183 107 259 69 221 145 297 12
78 230 40 344 192 116 268 21 325 173 97 249 59 211 135 287 158 306 154
55 359 207 131 283 36 340 188 112 264 74 226 150 302 17 321 169 93 245
198 122 274 27 331 179 103 255 65 217 141 293 8 312 160 84 236 46 350
279 32 336 184 108 260 70 222 146 298 13 317 165 89 241 53 355 203 127
326 174 98 250 60 212 136 288 285 307 155 79 231 41 345 193 117 269 22
110 262 72 224 148 300 15 319 167 91 243 53 357 205 129 281 34 338 186
62 214 138 290 5 309 157 81 233 43 347 195 119 271 24 328 176 100 252
143 295 10 314 162 86 238 48 352 200 124 276 29 333 181 105 257 67 219
0 304 152 76 228 38 342 190 114 266 19 323 171 95 247 57 209 133 3

```

## 21x21 data:

```

2 88 424 256 46 382 214 130 298 25 361 193 109 277 67 403 235 151 319 4 1
437 269 59 395 227 143 311 38 374 206 122 290 80 416 248 164 332 17 353 185 101
49 385 217 133 301 28 364 196 112 280 70 406 238 154 322 7 343 175 91 427 259
222 138 306 33 369 201 117 285 75 411 243 159 327 12 348 180 96 432 264 54 390
295 22 358 190 106 274 64 400 232 148 316 340 337 169 85 421 253 43 379 211 127
377 209 125 293 83 419 251 167 335 20 356 188 104 440 272 62 398 230 146 314 41
115 283 73 409 241 157 325 10 346 178 94 430 262 52 388 220 136 304 31 367 199
78 414 246 162 330 15 351 183 99 435 267 57 393 225 141 309 36 372 204 120 288
236 152 320 5 341 173 89 425 257 47 383 215 131 299 26 362 194 110 278 68 404
333 18 354 186 102 438 276 60 396 228 144 312 39 375 207 123 291 81 417 249 165
344 176 92 428 260 50 386 218 134 302 29 365 197 113 281 71 407 239 155 323 8
97 433 265 55 391 223 139 307 34 370 202 118 286 76 412 244 160 328 13 349 181
254 44 380 212 128 296 23 359 191 107 275 65 401 233 149 317 172 338 170 86 422
397 229 145 313 40 376 208 124 292 82 418 250 166 334 19 355 187 103 439 271 61
135 303 30 366 198 114 282 72 408 240 156 324 9 345 177 93 429 261 51 387 219
35 371 203 119 287 77 413 245 161 329 14 350 182 98 434 266 56 392 224 140 308
192 108 276 66 402 234 150 318 315 339 171 87 423 255 45 381 213 129 297 24 360
289 79 415 247 163 331 16 352 184 100 436 268 58 394 226 142 310 37 373 205 121
405 237 153 321 6 342 174 90 426 258 48 384 216 132 300 27 363 195 111 279 69
158 326 11 347 179 95 431 263 53 389 221 137 305 32 368 200 116 284 74 410 242
0 336 168 84 420 252 42 378 210 126 294 21 357 189 105 273 63 399 231 147 3

```

## 23x23 data:

|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 2   | 102 | 470 | 286 | 56  | 424 | 240 | 148 | 516 | 332 | 33  | 401 | 217 | 125 | 493 | 309 | 79  | 447 | 263 | 171 | 355 | 10  | 1   |
| 476 | 292 | 62  | 430 | 246 | 154 | 522 | 338 | 39  | 407 | 223 | 131 | 499 | 315 | 85  | 453 | 269 | 177 | 361 | 16  | 384 | 200 | 108 |
| 50  | 418 | 234 | 142 | 510 | 326 | 27  | 395 | 211 | 119 | 487 | 303 | 73  | 441 | 257 | 165 | 349 | 4   | 372 | 188 | 96  | 464 | 280 |
| 249 | 157 | 525 | 341 | 42  | 410 | 226 | 134 | 502 | 318 | 88  | 456 | 272 | 180 | 364 | 19  | 387 | 203 | 111 | 479 | 295 | 65  | 433 |
| 513 | 329 | 30  | 398 | 214 | 122 | 490 | 306 | 76  | 444 | 260 | 168 | 352 | 7   | 375 | 191 | 99  | 467 | 283 | 53  | 421 | 237 | 145 |
| 36  | 404 | 220 | 128 | 496 | 312 | 82  | 450 | 266 | 174 | 358 | 13  | 381 | 197 | 105 | 473 | 289 | 59  | 427 | 243 | 151 | 519 | 335 |
| 208 | 116 | 484 | 300 | 70  | 438 | 254 | 162 | 346 | 378 | 369 | 185 | 93  | 461 | 277 | 47  | 415 | 231 | 139 | 507 | 323 | 24  | 392 |
| 505 | 321 | 91  | 459 | 275 | 183 | 367 | 22  | 390 | 206 | 114 | 482 | 298 | 68  | 436 | 252 | 160 | 528 | 344 | 45  | 413 | 229 | 137 |
| 80  | 448 | 264 | 172 | 356 | 11  | 379 | 195 | 103 | 471 | 287 | 57  | 425 | 241 | 149 | 517 | 333 | 34  | 402 | 218 | 126 | 494 | 310 |
| 270 | 178 | 362 | 17  | 385 | 201 | 109 | 477 | 293 | 63  | 431 | 247 | 155 | 523 | 339 | 40  | 408 | 224 | 132 | 500 | 316 | 86  | 454 |
| 350 | 5   | 373 | 189 | 97  | 465 | 281 | 51  | 419 | 235 | 143 | 511 | 327 | 28  | 396 | 212 | 120 | 488 | 304 | 74  | 442 | 258 | 166 |
| 388 | 204 | 112 | 480 | 296 | 66  | 434 | 250 | 158 | 526 | 342 | 43  | 411 | 227 | 135 | 503 | 319 | 89  | 457 | 273 | 181 | 365 | 20  |
| 100 | 468 | 284 | 54  | 422 | 238 | 146 | 514 | 330 | 31  | 399 | 215 | 123 | 491 | 307 | 77  | 445 | 261 | 169 | 353 | 8   | 376 | 192 |
| 290 | 60  | 428 | 244 | 152 | 520 | 336 | 37  | 405 | 221 | 129 | 497 | 313 | 83  | 451 | 267 | 175 | 359 | 14  | 382 | 198 | 106 | 474 |
| 416 | 232 | 140 | 508 | 324 | 25  | 393 | 209 | 117 | 485 | 301 | 71  | 439 | 255 | 163 | 347 | 194 | 370 | 186 | 94  | 462 | 278 | 48  |
| 159 | 527 | 343 | 44  | 412 | 228 | 136 | 504 | 320 | 90  | 458 | 274 | 182 | 366 | 21  | 389 | 205 | 113 | 481 | 297 | 67  | 435 | 251 |
| 331 | 32  | 400 | 216 | 124 | 492 | 308 | 78  | 446 | 262 | 170 | 354 | 9   | 377 | 193 | 101 | 469 | 285 | 55  | 423 | 239 | 147 | 515 |
| 406 | 222 | 130 | 498 | 314 | 84  | 452 | 268 | 176 | 360 | 15  | 383 | 199 | 107 | 475 | 291 | 61  | 429 | 245 | 153 | 521 | 337 | 38  |
| 118 | 486 | 302 | 72  | 440 | 256 | 164 | 348 | 345 | 371 | 187 | 95  | 463 | 279 | 49  | 417 | 233 | 141 | 509 | 325 | 26  | 394 | 210 |
| 317 | 87  | 455 | 271 | 179 | 363 | 18  | 386 | 202 | 110 | 478 | 294 | 64  | 432 | 248 | 156 | 524 | 340 | 41  | 409 | 225 | 133 | 501 |
| 443 | 259 | 167 | 351 | 6   | 374 | 190 | 98  | 466 | 282 | 52  | 420 | 236 | 144 | 512 | 328 | 29  | 397 | 213 | 121 | 489 | 305 | 75  |
| 173 | 357 | 12  | 380 | 196 | 104 | 472 | 288 | 58  | 426 | 242 | 150 | 518 | 334 | 35  | 403 | 219 | 127 | 495 | 311 | 81  | 449 | 265 |
| 0   | 368 | 184 | 92  | 460 | 276 | 46  | 414 | 230 | 138 | 506 | 322 | 23  | 391 | 207 | 115 | 483 | 299 | 69  | 437 | 253 | 161 | 3   |

## 25x25 data:

|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 2   | 603 | 103 | 503 | 303 | 53  | 453 | 253 | 153 | 553 | 353 | 28  | 428 | 228 | 128 | 528 | 328 | 78  | 478 | 278 | 178 | 578 | 378 | 375 | 1   |
| 123 | 523 | 323 | 73  | 473 | 273 | 173 | 573 | 373 | 48  | 448 | 248 | 148 | 548 | 348 | 98  | 498 | 298 | 198 | 598 | 398 | 23  | 423 | 223 | 623 |
| 311 | 61  | 461 | 261 | 161 | 561 | 361 | 36  | 436 | 236 | 136 | 536 | 336 | 86  | 486 | 286 | 186 | 586 | 386 | 11  | 411 | 211 | 611 | 111 | 511 |
| 467 | 267 | 167 | 567 | 367 | 42  | 442 | 242 | 142 | 542 | 342 | 92  | 492 | 292 | 192 | 592 | 392 | 17  | 417 | 217 | 617 | 117 | 517 | 317 | 67  |
| 155 | 555 | 355 | 30  | 430 | 230 | 130 | 530 | 330 | 80  | 480 | 280 | 180 | 580 | 380 | 5   | 405 | 205 | 605 | 105 | 505 | 305 | 55  | 455 | 255 |
| 370 | 45  | 445 | 245 | 145 | 545 | 345 | 95  | 495 | 295 | 195 | 595 | 395 | 20  | 420 | 220 | 620 | 120 | 520 | 320 | 70  | 470 | 270 | 170 | 570 |
| 433 | 233 | 133 | 533 | 333 | 83  | 483 | 283 | 183 | 583 | 383 | 8   | 408 | 208 | 608 | 108 | 508 | 308 | 58  | 458 | 258 | 158 | 558 | 358 | 33  |
| 139 | 539 | 339 | 89  | 489 | 289 | 189 | 589 | 389 | 14  | 414 | 214 | 614 | 114 | 514 | 314 | 64  | 464 | 264 | 164 | 564 | 364 | 39  | 439 | 239 |
| 326 | 76  | 476 | 276 | 176 | 576 | 376 | 403 | 401 | 201 | 601 | 101 | 501 | 301 | 51  | 451 | 251 | 151 | 551 | 351 | 26  | 426 | 226 | 126 | 526 |
| 499 | 299 | 199 | 599 | 399 | 24  | 424 | 224 | 624 | 124 | 524 | 324 | 74  | 474 | 274 | 174 | 574 | 374 | 49  | 449 | 249 | 149 | 549 | 349 | 99  |
| 187 | 587 | 387 | 12  | 412 | 212 | 612 | 112 | 512 | 312 | 62  | 462 | 262 | 162 | 562 | 362 | 37  | 437 | 237 | 137 | 537 | 337 | 87  | 487 | 287 |
| 393 | 18  | 418 | 218 | 618 | 118 | 518 | 318 | 68  | 468 | 268 | 168 | 568 | 368 | 43  | 443 | 243 | 143 | 543 | 343 | 93  | 493 | 293 | 193 | 593 |
| 406 | 206 | 606 | 106 | 506 | 306 | 56  | 456 | 256 | 156 | 556 | 356 | 31  | 431 | 231 | 131 | 531 | 331 | 81  | 481 | 281 | 181 | 581 | 381 | 6   |
| 621 | 121 | 521 | 321 | 71  | 471 | 271 | 171 | 571 | 371 | 46  | 446 | 246 | 146 | 546 | 346 | 96  | 496 | 296 | 196 | 596 | 396 | 21  | 421 | 221 |
| 509 | 309 | 59  | 459 | 259 | 159 | 559 | 359 | 34  | 434 | 234 | 134 | 534 | 334 | 84  | 484 | 284 | 184 | 584 | 384 | 9   | 409 | 209 | 609 | 109 |
| 65  | 465 | 265 | 165 | 565 | 365 | 40  | 440 | 240 | 140 | 540 | 340 | 90  | 490 | 290 | 190 | 590 | 390 | 15  | 415 | 215 | 615 | 115 | 515 | 315 |
| 252 | 152 | 552 | 352 | 27  | 427 | 227 | 127 | 527 | 327 | 77  | 477 | 277 | 177 | 577 | 377 | 203 | 402 | 202 | 602 | 102 | 502 | 302 | 52  | 452 |
| 572 | 372 | 47  | 447 | 247 | 147 | 547 | 347 | 97  | 497 | 297 | 197 | 597 | 397 | 22  | 422 | 222 | 622 | 122 | 522 | 322 | 72  | 472 | 272 | 172 |
| 35  | 435 | 235 | 135 | 535 | 335 | 85  | 485 | 285 | 185 | 585 | 385 | 10  | 410 | 210 | 610 | 110 | 510 | 310 | 60  | 460 | 260 | 160 | 560 | 360 |
| 241 | 141 | 541 | 341 | 91  | 491 | 291 | 191 | 591 | 391 | 16  | 416 | 216 | 616 | 116 | 516 | 316 | 66  | 466 | 266 | 166 | 566 | 366 | 41  | 441 |
| 529 | 329 | 79  | 479 | 279 | 179 | 579 | 379 | 4   | 404 | 204 | 604 | 104 | 504 | 304 | 54  | 454 | 254 | 154 | 554 | 354 | 29  | 429 | 229 | 129 |
| 94  | 494 | 294 | 194 | 594 | 394 | 19  | 419 | 219 | 619 | 119 | 519 | 319 | 69  | 469 | 269 | 169 | 569 | 369 | 44  | 444 | 244 | 144 | 544 | 344 |
| 282 | 182 | 582 | 382 | 7   | 407 | 207 | 607 | 107 | 507 | 307 | 57  | 457 | 257 | 157 | 557 | 357 | 32  | 432 | 232 | 132 | 532 | 332 | 82  | 482 |
| 588 | 388 | 13  | 413 | 213 | 613 | 113 | 513 | 313 | 63  | 463 | 263 | 163 | 563 | 363 | 38  | 438 | 238 | 138 | 538 | 338 | 88  | 488 | 288 | 188 |
| 0   | 400 | 200 | 600 | 100 | 500 | 300 | 50  | 450 | 250 | 150 | 550 | 350 | 25  | 425 | 225 | 125 | 525 | 325 | 75  | 475 | 275 | 175 | 575 | 375 |

## 27x27 data:

|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 2   | 658 | 118 | 550 | 334 | 64  | 496 | 280 | 712 | 172 | 604 | 388 | 37  | 469 | 253 | 685 | 145 | 577 | 361 | 91  | 523 | 307 | 199 | 631 | 415 | 10  | 1   |
| 125 | 557 | 341 | 71  | 503 | 287 | 719 | 179 | 611 | 395 | 44  | 476 | 260 | 692 | 152 | 584 | 368 | 98  | 530 | 314 | 206 | 638 | 422 | 17  | 449 | 233 | 665 |
| 327 | 57  | 489 | 273 | 705 | 165 | 597 | 381 | 30  | 462 | 246 | 678 | 138 | 570 | 354 | 84  | 516 | 300 | 192 | 624 | 408 | 405 | 435 | 219 | 651 | 111 | 543 |
| 511 | 295 | 727 | 187 | 619 | 403 | 52  | 484 | 268 | 700 | 160 | 592 | 376 | 106 | 538 | 322 | 214 | 646 | 430 | 25  | 457 | 241 | 673 | 133 | 565 | 349 | 79  |
| 714 | 174 | 606 | 330 | 39  | 471 | 255 | 687 | 147 | 579 | 363 | 93  | 525 | 309 | 201 | 633 | 417 | 12  | 444 | 228 | 660 | 120 | 552 | 336 | 66  | 498 | 282 |
| 613 | 397 | 46  | 478 | 262 | 694 | 154 | 586 | 370 | 100 | 532 | 316 | 208 | 640 | 424 | 19  | 451 | 235 | 667 | 127 | 559 | 343 | 73  | 505 | 289 | 721 | 181 |
| 32  | 464 | 248 | 680 | 140 | 572 | 356 | 86  | 518 | 302 | 194 | 626 | 410 | 5   | 437 | 221 | 653 | 113 | 545 | 329 | 59  | 491 | 275 | 707 | 167 | 599 | 383 |
| 265 | 697 | 157 | 589 | 373 | 103 | 535 | 319 | 211 | 643 | 427 | 22  | 454 | 238 | 670 | 130 | 562 | 346 | 76  | 508 | 292 | 724 | 184 | 616 | 400 | 49  | 481 |
| 143 | 575 | 359 | 89  | 521 | 305 | 197 | 629 | 413 | 8   | 440 | 224 | 656 | 116 | 548 | 332 | 62  | 494 | 278 | 710 | 170 | 602 | 386 | 56  | 467 | 251 | 683 |
| 366 | 96  | 528 | 312 | 204 | 636 | 420 | 15  | 447 | 231 | 663 | 123 | 555 | 339 | 69  | 501 | 285 | 717 | 177 | 609 | 393 | 42  | 474 | 258 | 690 | 150 | 582 |
| 514 | 298 | 190 | 622 | 406 | 442 | 433 | 217 | 649 | 109 | 541 | 325 | 55  | 487 | 271 | 703 | 163 | 595 | 379 | 28  | 460 | 244 | 676 | 136 | 568 | 352 | 82  |
| 215 | 647 | 431 | 26  | 458 | 242 | 674 | 134 | 566 | 350 | 80  | 512 | 296 | 728 | 188 | 620 | 404 | 53  | 485 | 269 | 701 | 161 | 593 | 377 | 107 | 539 | 323 |
| 418 | 13  | 445 | 229 | 661 | 121 | 553 | 337 | 67  | 499 | 283 | 715 | 175 | 607 | 391 | 40  | 472 | 256 | 688 | 148 | 580 | 364 | 94  | 526 | 310 | 202 | 634 |
| 452 | 236 | 668 | 128 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

## 29x29 data:

2 703 123 587 355 819 65 529 297 761 181 645 413 36 500 268 732 152 616 384 94 558 326 790 210 674 442 7 1  
 141 605 373 837 83 547 315 779 199 663 431 54 518 286 750 170 634 402 112 576 344 808 228 692 460 25 489 257 721  
 359 823 69 533 301 765 185 649 417 40 504 272 736 156 620 388 98 562 330 794 214 678 446 11 475 243 707 127 591  
 76 540 308 772 192 656 424 47 511 279 743 163 627 395 105 569 337 801 221 685 453 18 482 250 714 134 598 366 830  
 293 757 177 641 409 32 496 264 728 148 612 380 90 554 322 786 206 670 438 435 467 235 699 119 583 351 815 61 525  
 201 665 433 56 520 288 752 172 636 404 114 578 346 810 230 694 462 27 491 259 723 143 607 375 839 85 549 317 781  
 419 42 506 274 738 158 622 390 100 564 332 796 216 680 448 13 477 245 709 129 593 361 825 71 535 303 767 187 651  
 513 281 745 165 629 397 107 571 339 803 223 687 455 20 484 252 716 136 600 368 832 78 542 310 774 194 658 426 49  
 730 150 614 382 92 556 324 788 208 672 440 5 469 237 701 121 585 353 817 63 527 295 759 179 643 411 34 498 266  
 632 400 110 574 342 806 226 690 458 23 487 255 719 139 603 371 835 81 545 313 777 197 661 429 52 516 284 748 168  
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## 31x31 data:

2 759 139 635 387 883 77 573 325 821 201 697 449 945 46 542 294 790 170 666 418 914 108 604 356 852 232 728 480 15 1  
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 845 225 721 473 8 504 256 752 132 628 380 876 70 566 318 814 194 690 442 938 39 535 287 783 163 659 411 907 101 597 349  
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|             |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |
|-------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|
| 33x33 data: | 2    | 285  | 793  | 133  | 661  | 397  | 925  | 67   | 595  | 331  | 859  | 199  | 727  | 463  | 991  | 34   | 562  | 298  | 826  | 166  | 694  | 430  | 958  | 100  | 628  | 364  | 892  | 232  | 760  | 496  | 1024 | 1057 | 1   |
|             | 824  | 164  | 692  | 428  | 956  | 98   | 626  | 362  | 890  | 230  | 758  | 494  | 1022 | 65   | 593  | 329  | 857  | 197  | 725  | 461  | 989  | 131  | 659  | 395  | 923  | 263  | 791  | 527  | 1055 | 32   | 1088 | 560  | 296 |
|             | 676  | 412  | 940  | 82   | 610  | 346  | 874  | 214  | 742  | 478  | 1006 | 49   | 577  | 313  | 841  | 181  | 709  | 445  | 973  | 115  | 643  | 379  | 907  | 247  | 775  | 511  | 1039 | 16   | 1072 | 544  | 280  | 808  | 148 |
|             | 948  | 90   | 618  | 354  | 882  | 222  | 750  | 486  | 1014 | 57   | 585  | 321  | 849  | 189  | 717  | 453  | 981  | 123  | 651  | 387  | 915  | 255  | 783  | 519  | 1047 | 24   | 1080 | 552  | 288  | 816  | 156  | 684  | 420 |
|             | 602  | 338  | 866  | 206  | 734  | 470  | 998  | 41   | 569  | 305  | 833  | 173  | 701  | 437  | 965  | 107  | 635  | 371  | 899  | 239  | 767  | 503  | 1031 | 8    | 1064 | 536  | 272  | 800  | 140  | 668  | 404  | 932  | 74  |
|             | 886  | 226  | 754  | 490  | 1018 | 61   | 589  | 325  | 853  | 193  | 721  | 457  | 985  | 127  | 655  | 391  | 919  | 259  | 787  | 523  | 1051 | 28   | 1084 | 556  | 222  | 820  | 160  | 688  | 424  | 952  | 94   | 622  | 358 |
|             | 738  | 474  | 1002 | 45   | 573  | 309  | 837  | 177  | 705  | 441  | 569  | 411  | 639  | 375  | 903  | 243  | 771  | 507  | 1035 | 12   | 1068 | 540  | 276  | 804  | 144  | 672  | 408  | 936  | 78   | 606  | 342  | 870  | 210 |
|             | 1010 | 53   | 581  | 317  | 845  | 185  | 713  | 449  | 977  | 119  | 647  | 383  | 911  | 251  | 779  | 515  | 1043 | 20   | 1076 | 548  | 284  | 812  | 152  | 680  | 416  | 944  | 86   | 614  | 350  | 878  | 218  | 746  | 482 |
|             | 585  | 301  | 829  | 169  | 697  | 433  | 961  | 103  | 631  | 367  | 895  | 235  | 763  | 499  | 1027 | 4    | 1060 | 532  | 268  | 796  | 136  | 664  | 400  | 928  | 70   | 598  | 334  | 862  | 202  | 730  | 466  | 994  | 37  |
|             | 855  | 195  | 723  | 459  | 987  | 129  | 657  | 393  | 921  | 261  | 789  | 525  | 1053 | 30   | 1086 | 558  | 294  | 822  | 162  | 690  | 426  | 954  | 96   | 624  | 360  | 888  | 228  | 756  | 492  | 1020 | 63   | 591  | 327 |
|             | 707  | 443  | 971  | 113  | 641  | 377  | 905  | 245  | 773  | 509  | 1037 | 14   | 1070 | 542  | 278  | 806  | 146  | 674  | 410  | 938  | 80   | 608  | 344  | 872  | 212  | 740  | 476  | 1004 | 47   | 575  | 311  | 839  | 179 |
|             | 979  | 121  | 649  | 385  | 913  | 253  | 781  | 517  | 1045 | 22   | 1078 | 550  | 286  | 814  | 154  | 682  | 418  | 946  | 88   | 616  | 352  | 880  | 220  | 748  | 484  | 1012 | 55   | 583  | 319  | 847  | 187  | 715  | 451 |
|             | 633  | 369  | 897  | 237  | 765  | 501  | 1029 | 6    | 1062 | 534  | 270  | 798  | 138  | 666  | 402  | 930  | 72   | 600  | 336  | 864  | 204  | 732  | 468  | 996  | 39   | 567  | 303  | 831  | 171  | 699  | 435  | 963  | 105 |
|             | 917  | 257  | 785  | 521  | 1049 | 26   | 1082 | 554  | 290  | 818  | 158  | 686  | 422  | 950  | 92   | 620  | 356  | 884  | 224  | 752  | 488  | 1016 | 59   | 587  | 323  | 851  | 191  | 719  | 455  | 983  | 125  | 653  | 389 |
|             | 769  | 505  | 1033 | 10   | 1066 | 538  | 274  | 802  | 142  | 670  | 406  | 934  | 76   | 604  | 340  | 868  | 208  | 736  | 472  | 1000 | 43   | 571  | 307  | 835  | 175  | 703  | 439  | 967  | 109  | 637  | 373  | 901  | 241 |
|             | 1041 | 18   | 1074 | 546  | 282  | 810  | 150  | 678  | 414  | 942  | 84   | 612  | 348  | 876  | 216  | 744  | 480  | 1008 | 51   | 579  | 315  | 843  | 183  | 711  | 447  | 975  | 117  | 645  | 381  | 909  | 249  | 777  | 513 |
|             | 1058 | 530  | 266  | 794  | 134  | 662  | 398  | 926  | 68   | 596  | 332  | 860  | 200  | 728  | 464  | 992  | 35   | 563  | 299  | 827  | 167  | 695  | 431  | 959  | 101  | 629  | 365  | 893  | 233  | 761  | 497  | 1025 | 529 |
|             | 295  | 823  | 163  | 691  | 427  | 955  | 97   | 625  | 361  | 889  | 229  | 757  | 493  | 1021 | 64   | 592  | 328  | 856  | 196  | 724  | 460  | 988  | 130  | 658  | 394  | 922  | 262  | 790  | 526  | 1054 | 31   | 1087 | 559 |
|             | 147  | 675  | 411  | 939  | 81   | 609  | 345  | 873  | 213  | 741  | 477  | 1005 | 48   | 576  | 312  | 840  | 180  | 708  | 444  | 972  | 114  | 642  | 378  | 906  | 246  | 774  | 510  | 1038 | 15   | 1071 | 543  | 279  | 807 |
|             | 419  | 947  | 89   | 617  | 353  | 881  | 221  | 749  | 485  | 1013 | 56   | 584  | 320  | 848  | 188  | 716  | 452  | 980  | 122  | 650  | 386  | 914  | 254  | 782  | 518  | 1046 | 23   | 1079 | 551  | 287  | 815  | 155  | 683 |
|             | 73   | 601  | 337  | 865  | 205  | 733  | 469  | 997  | 40   | 568  | 304  | 832  | 172  | 700  | 436  | 964  | 106  | 634  | 370  | 898  | 238  | 766  | 502  | 1030 | 7    | 1063 | 535  | 271  | 799  | 139  | 667  | 403  | 931 |
|             | 357  | 885  | 225  | 753  | 489  | 1017 | 60   | 588  | 324  | 852  | 192  | 720  | 456  | 984  | 126  | 654  | 390  | 918  | 258  | 786  | 522  | 1050 | 27   | 1083 | 555  | 291  | 819  | 159  | 687  | 423  | 951  | 93   | 621 |
|             | 209  | 737  | 473  | 1001 | 44   | 572  | 308  | 836  | 176  | 704  | 440  | 968  | 110  | 638  | 374  | 902  | 242  | 770  | 506  | 1034 | 11   | 1067 | 539  | 275  | 803  | 143  | 671  | 407  | 935  | 77   | 605  | 341  | 869 |
|             | 481  | 1009 | 52   | 580  | 316  | 844  | 184  | 712  | 448  | 976  | 118  | 646  | 382  | 910  | 250  | 778  | 514  | 1042 | 19   | 1075 | 547  | 283  | 811  | 151  | 679  | 415  | 943  | 85   | 613  | 349  | 877  | 217  | 745 |
|             | 36   | 564  | 300  | 828  | 168  | 696  | 432  | 960  | 102  | 630  | 366  | 894  | 234  | 762  | 498  | 1026 | 1023 | 1059 | 531  | 267  | 795  | 135  | 663  | 399  | 927  | 69   | 597  | 333  | 861  | 201  | 729  | 465  | 993 |
|             | 326  | 854  | 194  | 722  | 458  | 986  | 128  | 656  | 392  | 920  | 260  | 788  | 524  | 1052 | 29   | 1085 | 557  | 293  | 821  | 161  | 689  | 425  | 953  | 95   | 623  | 359  | 887  | 227  | 755  | 491  | 1019 | 62   | 590 |
|             | 178  | 706  | 442  | 970  | 112  | 640  | 376  | 904  | 244  | 772  | 508  | 1036 | 13   | 1069 | 541  | 277  | 805  | 145  | 673  | 409  | 937  | 79   | 607  | 343  | 871  | 211  | 739  | 475  | 1003 | 46   | 574  | 310  | 838 |
|             | 450  | 978  | 120  | 648  | 384  | 912  | 252  | 780  | 516  | 1044 | 21   | 1077 | 549  | 285  | 813  | 153  | 681  | 417  | 945  | 87   | 615  | 351  | 879  | 219  | 747  | 483  | 1011 | 54   | 582  | 318  | 846  | 186  | 714 |
|             | 104  | 632  | 368  | 896  | 236  | 764  | 500  | 1028 | 5    | 1061 | 533  | 269  | 797  | 137  | 665  | 401  | 929  | 71   | 599  | 355  | 863  | 203  | 731  | 467  | 995  | 38   | 566  | 302  | 830  | 170  | 698  | 434  | 962 |
|             | 388  | 916  | 256  | 784  | 520  | 1048 | 25   | 1081 | 553  | 289  | 817  | 157  | 685  | 421  | 949  | 91   | 619  | 355  | 883  | 223  | 751  | 487  | 1015 | 58   | 586  | 322  | 850  | 190  | 718  | 454  | 982  | 124  | 652 |
|             | 240  | 768  | 504  | 1032 | 9    | 1065 | 537  | 273  | 801  | 141  | 669  | 405  | 933  | 75   | 603  | 339  | 867  | 207  | 735  | 471  | 999  | 42   | 570  | 306  | 834  | 174  | 702  | 438  | 966  | 108  | 636  | 372  | 900 |
|             | 512  | 1040 | 17   | 1073 | 545  | 281  | 809  | 149  | 677  | 413  | 83   | 611  | 347  | 875  | 215  | 743  | 479  | 1007 | 50   | 578  | 314  | 842  | 182  | 710  | 446  | 974  | 116  | 644  | 380  | 908  | 248  | 776  | 513 |
|             | 0    | 1056 | 528  | 264  | 792  | 132  | 696  | 396  | 924  | 66   | 594  | 330  | 858  | 198  | 726  | 462  | 990  | 33   | 561  | 297  | 825  | 165  | 693  | 429  | 957  | 99   | 627  | 363  | 891  | 231  | 759  | 495  | 3   |

**35x35 data:**

|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|
| 2    | 290  | 850  | 150  | 710  | 430  | 990  | 80   | 1200 | 640  | 360  | 320  | 780  | 500  | 1060 | 45   | 1160 | 605  | 325  | 855  | 185  | 745  | 465  | 1025 | 115  | 675  | 395  | 955  | 255  | 815  | 535  | 1095 | 1   |
| 859  | 159  | 730  | 430  | 990  | 89   | 1209 | 649  | 369  | 329  | 789  | 509  | 1069 | 54   | 1174 | 614  | 334  | 894  | 354  | 754  | 474  | 1034 | 124  | 684  | 404  | 694  | 264  | 824  | 524  | 814  | 539  | 1099 | 2   |
| 701  | 421  | 981  | 71   | 1191 | 631  | 351  | 911  | 771  | 481  | 1051 | 651  | 3156 | 596  | 315  | 876  | 1736 | 1056 | 1066 | 686  | 946  | 276  | 836  | 549  | 1106 | 606  | 526  | 1086 | 1110 | 1121 | 561  | 281  | 841 |
| 1014 | 104  | 1224 | 664  | 384  | 944  | 244  | 804  | 524  | 1084 | 69   | 1189 | 629  | 349  | 909  | 209  | 769  | 489  | 1049 | 139  | 659  | 419  | 979  | 279  | 839  | 569  | 1119 | 34   | 1154 | 594  | 314  | 874  | 174 |
| 1207 | 647  | 367  | 927  | 787  | 507  | 1067 | 527  | 1172 | 612  | 332  | 882  | 122  | 692  | 402  | 682  | 262  | 822  | 542  | 1102 | 37   | 1137 | 577  | 927  | 857  | 157  | 717  | 437  | 997  | 87   | 397  | 87   |     |
| 376  | 936  | 736  | 756  | 217  | 607  | 1167 | 621  | 341  | 901  | 201  | 771  | 481  | 1041 | 331  | 691  | 411  | 971  | 271  | 831  | 551  | 1111 | 36   | 1146 | 586  | 106  | 726  | 446  | 1006 | 96   | 1216 | 656  |     |
| 216  | 778  | 498  | 1058 | 43   | 1163 | 623  | 863  | 183  | 743  | 463  | 1023 | 113  | 673  | 393  | 953  | 253  | 813  | 533  | 1093 | 8    | 1128 | 588  | 288  | 148  | 708  | 428  | 988  | 78   | 1198 | 538  | 138  |     |
| 520  | 1060 | 658  | 325  | 905  | 205  | 765  | 485  | 1045 | 135  | 695  | 415  | 975  | 275  | 835  | 555  | 1115 | 35   | 1150 | 595  | 315  | 875  | 405  | 1010 | 1220 | 660  | 380  | 940  | 280  | 740  | 503  | 1063 |     |
| 48   | 1168 | 608  | 328  | 988  | 178  | 468  | 1038 | 118  | 678  | 398  | 958  | 258  | 818  | 538  | 1098 | 9    | 1133 | 575  | 935  | 153  | 713  | 433  | 993  | 83   | 1203 | 643  | 363  | 283  | 743  | 503  | 1063 |     |
| 679  | 337  | 997  | 137  | 707  | 1037 | 127  | 607  | 967  | 267  | 827  | 547  | 1107 | 607  | 442  | 1002 | 92   | 442  | 1002 | 92   | 442  | 1002 | 92   | 442  | 1002 | 92   | 442  | 1002 | 92   | 442  | 1002 | 92   | 442 |
| 879  | 179  | 339  | 459  | 1019 | 669  | 389  | 949  | 249  | 809  | 529  | 1089 | 69   | 1184 | 564  | 284  | 844  | 144  | 704  | 424  | 984  | 74   | 1194 | 634  | 354  | 914  | 214  | 774  | 494  | 1054 | 539  | 1119 |     |
| 767  | 487  | 1047 | 137  | 697  | 417  | 777  | 277  | 837  | 557  | 1117 | 32   | 1152 | 592  | 312  | 872  | 172  | 732  | 452  | 1012 | 102  | 662  | 382  | 942  | 282  | 802  | 522  | 1082 | 67   | 1187 | 627  | 907  |     |
| 1030 | 120  | 680  | 400  | 660  | 820  | 540  | 1100 | 5    | 1153 | 575  | 935  | 155  | 715  | 435  | 995  | 85   | 1205 | 645  | 365  | 285  | 745  | 505  | 1065 | 50   | 1170 | 610  | 820  | 390  | 150  | 770  | 470  |     |
| 689  | 409  | 969  | 259  | 829  | 549  | 1109 | 24   | 1144 | 584  | 304  | 864  | 164  | 724  | 444  | 1004 | 94   | 1214 | 654  | 374  | 934  | 514  | 1074 | 59   | 1179 | 619  | 339  | 899  | 139  | 759  | 479  | 1039 |     |
| 951  | 251  | 811  | 531  | 1091 | 6    | 1126 | 566  | 286  | 846  | 146  | 706  | 426  | 986  | 76   | 1196 | 636  | 356  | 916  | 216  | 776  | 496  | 1056 | 41   | 1161 | 601  | 321  | 881  | 181  | 741  | 461  | 1021 |     |
| 833  | 533  | 1113 | 28   | 1148 | 588  | 308  | 868  | 168  | 728  | 448  | 1008 | 98   | 1218 | 658  | 378  | 938  | 518  | 1078 | 598  | 1178 | 638  | 343  | 903  | 763  | 483  | 1043 | 133  | 693  | 413  | 973  | 273  |     |
| 1096 | 11   | 1131 | 571  | 291  | 851  | 151  | 711  | 431  | 991  | 81   | 1201 | 611  | 361  | 921  | 221  | 781  | 501  | 1061 | 46   | 1166 | 606  | 326  | 886  | 186  | 746  | 466  | 1026 | 116  | 676  | 396  | 956  |     |
| 282  | 842  | 1402 | 720  | 4400 | 90   | 1210 | 650  | 370  | 720  | 390  | 510  | 1070 | 55   | 1175 | 615  | 335  | 895  | 195  | 755  | 475  | 1035 | 125  | 685  | 405  | 965  | 265  | 825  | 545  | 1105 | 20   |      |     |
| 173  | 733  | 453  | 1013 | 1223 | 663  | 383  | 943  | 243  | 803  | 523  | 1083 | 68   | 1188 | 628  | 348  | 908  | 208  | 768  | 488  | 1048 | 138  | 698  | 418  | 978  | 278  | 838  | 558  | 1118 | 33   | 1133 | 593  |     |
| 436  | 936  | 86   | 1206 | 646  | 326  | 986  | 266  | 506  | 1066 | 51   | 1171 | 611  | 331  | 891  | 191  | 751  | 471  | 1031 | 121  | 681  | 401  | 961  | 261  | 821  | 541  | 1101 | 16   | 1136 | 576  | 296  | 856  |     |
| 95   | 1215 | 655  | 375  | 935  | 155  | 715  | 435  | 995  | 85   | 1205 | 645  | 365  | 285  | 745  | 505  | 1065 | 50   | 1170 | 610  | 820  | 390  | 150  | 770  | 470  | 527  | 1087 | 507  | 1122 | 562  |      |      |     |
| 637  | 357  | 917  | 217  | 777  | 497  | 1057 | 42   | 1162 | 602  | 322  | 882  | 182  | 742  | 462  | 1022 | 112  | 672  | 392  | 952  | 252  | 812  | 532  | 1092 | 7    | 1127 | 567  | 287  | 847  | 147  | 707  | 1197 |     |
| 939  | 239  | 799  | 519  | 1079 | 6    | 1184 | 624  | 344  | 904  | 204  | 764  | 484  | 1044 | 334  | 694  | 414  | 974  | 274  | 834  | 554  | 1114 | 29   | 1149 | 589  | 309  | 869  | 169  | 729  | 449  | 1009 |      |     |
| 782  | 502  | 1062 | 47   | 1167 | 607  | 327  | 887  | 187  | 747  | 467  | 1027 | 117  | 677  | 397  | 957  | 257  | 817  | 537  | 1097 | 9    | 1132 | 572  | 292  | 852  | 152  | 712  | 432  | 992  | 82   | 362  | 922  |     |
| 1171 | 56   | 1176 | 616  | 336  | 896  | 196  | 756  | 476  | 1036 | 126  | 686  | 406  | 966  | 266  | 826  | 546  | 1106 | 21   | 1141 | 581  | 301  | 861  | 161  | 721  | 441  | 1001 | 91   | 1211 | 651  | 371  |      |     |
| 1058 | 598  | 318  | 778  | 178  | 338  | 458  | 1018 | 668  | 388  | 948  | 248  | 808  | 528  | 1088 | 698  | 1158 | 568  | 288  | 848  | 148  | 708  | 428  | 988  | 748  | 1198 | 538  | 133  | 733  | 633  | 353  |      |     |
| 346  | 906  | 206  | 766  | 486  | 1046 | 136  | 696  | 416  | 976  | 276  | 836  | 556  | 1116 | 31   | 1151 | 591  | 311  | 871  | 431  | 991  | 84   | 1204 | 644  | 364  | 284  | 744  | 504  | 1064 | 49   | 1169 |      |     |
| 189  | 749  | 469  | 1029 | 119  | 679  | 399  | 959  | 259  | 819  | 539  | 1099 | 4    | 1134 | 574  | 294  | 854  | 154  | 714  | 434  | 994  | 84   | 1204 | 644  | 364  | 284  | 744  | 504  | 1064 | 49   | 1169 |      |     |
| 478  | 1038 | 128  | 688  | 408  | 668  | 268  | 828  | 548  | 1108 | 21   | 1143 | 583  | 303  | 863  | 163  | 723  | 443  | 1003 | 93   | 1213 | 653  | 373  | 933  | 513  | 1073 | 58   | 1178 | 638  | 398  | 188  |      |     |
| 110  | 670  | 390  | 500  | 810  | 530  | 1090 | 5    | 1125 | 565  | 285  | 845  | 145  | 705  | 425  | 985  | 75   | 1195 | 635  | 355  | 915  | 215  | 775  | 495  | 1055 | 40   | 1160 | 600  | 380  | 940  | 160  |      |     |
| 42   | 912  | 272  | 832  | 552  | 112  | 672  | 392  | 952  | 252  | 812  | 532  | 1092 | 7    | 1127 | 567  | 287  | 847  | 147  | 707  | 467  | 1027 | 117  | 677  | 397  | 957  | 257  | 817  | 537  | 1097 | 9    | 1137 |     |
| 254  | 814  | 534  | 1094 | 9    | 1129 | 569  | 289  | 849  | 149  | 709  | 429  | 989  | 79   | 1199 | 639  | 359  | 919  | 219  | 779  | 499  | 1059 | 4    | 1164 | 604  | 384  | 944  | 284  | 744  | 504  | 1064 |      |     |
| 543  | 1013 | 18   | 1138 | 578  | 298  | 858  | 158  | 718  | 438  | 998  | 88   | 1208 | 648  | 368  | 288  | 748  | 508  | 1068 | 53   | 1173 | 613  | 333  | 893  | 193  | 753  | 473  | 1033 | 123  | 683  | 403  | 963  |     |
| 0    | 1130 | 560  | 280  | 840  | 700  | 420  | 980  | 780  | 1190 | 630  | 350  | 910  | 210  | 770  | 490  | 1050 | 35   | 1155 | 595  | 315  | 875  | 175  | 735  | 455  | 1015 | 105  | 665  | 385  | 945  | 285  | 525  |     |

## 37x37 data:

|      |      |      |      |       |      |      |      |      |      |      |      |      |      |      |      |       |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |     |
|------|------|------|------|-------|------|------|------|------|------|------|------|------|------|------|------|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|
| 2    | 302  | 894  | 154  | 1338  | 746  | 450  | 1042 | 80   | 1264 | 672  | 376  | 968  | 228  | 820  | 524  | 1116  | 43   | 1227 | 635  | 369  | 931  | 191  | 783  | 487  | 1079 | 117  | 1301 | 709  | 113  | 1005 | 265  | 857  | 561  | 1153 | 5    |      |     |
| 1317 | 1761 | 1047 | 473  | 1065  | 1037 | 695  | 339  | 921  | 551  | 843  | 547  | 1133 | 68   | 1230 | 658  | 362   | 944  | 55   | 1102 | 440  | 124  | 732  | 346  | 1028 | 288  | 868  | 984  | 116  | 423  | 1213 | 866  | 125  | 325  |      |      |      |     |
| 1347 | 771  | 1261 | 888  | 1392  | 1062 | 1037 | 695  | 339  | 921  | 551  | 843  | 547  | 1133 | 68   | 1230 | 658   | 362  | 944  | 55   | 1102 | 440  | 124  | 732  | 346  | 1028 | 288  | 868  | 984  | 116  | 423  | 1213 | 866  | 125  | 325  |      |      |     |
| 1434 | 1056 | 947  | 1276 | 888   | 1392 | 1062 | 1037 | 695  | 339  | 921  | 551  | 843  | 547  | 1133 | 68   | 1230  | 658  | 362  | 944  | 55   | 1102 | 440  | 124  | 732  | 346  | 1028 | 288  | 868  | 984  | 116  | 423  | 1213 | 866  | 125  | 325  |      |     |
| 75   | 1259 | 667  | 371  | 963   | 233  | 815  | 519  | 111  | 38   | 1222 | 634  | 926  | 186  | 778  | 482  | 1074  | 408  | 1000 | 271  | 871  | 576  | 1071 | 576  | 1071 | 576  | 1071 | 576  | 1071 | 576  | 1071 | 576  | 1071 | 576  | 1071 |      |      |     |
| 702  | 406  | 988  | 258  | 800   | 554  | 1146 | 73   | 1257 | 665  | 369  | 961  | 221  | 813  | 517  | 1109 | 447   | 1331 | 739  | 443  | 1035 | 295  | 687  | 591  | 883  | 36   | 1220 | 628  | 32   | 924  | 184  | 1368 | 776  | 480  | 1072 | 11   |      |     |
| 980  | 240  | 832  | 536  | 1238  | 55   | 1239 | 647  | 521  | 943  | 203  | 795  | 499  | 1091 | 120  | 1313 | 721   | 425  | 1017 | 277  | 869  | 573  | 1165 | 18   | 1202 | 610  | 334  | 906  | 166  | 150  | 758  | 462  | 1054 | 92   | 1276 | 684  | 388  |     |
| 841  | 545  | 1337 | 64   | 1248  | 656  | 360  | 942  | 212  | 804  | 508  | 1100 | 138  | 1322 | 730  | 434  | 1026  | 286  | 878  | 582  | 174  | 27   | 1211 | 619  | 333  | 915  | 175  | 1359 | 767  | 471  | 1063 | 601  | 1285 | 693  | 979  | 989  | 249  |     |
| 1253 | 661  | 368  | 957  | 217   | 809  | 513  | 1005 | 143  | 1327 | 735  | 439  | 1031 | 251  | 883  | 587  | 1179  | 52   | 1216 | 624  | 382  | 901  | 305  | 899  | 157  | 1341 | 749  | 455  | 1040 | 603  | 942  | 279  | 574  | 971  | 31   | 823  | 527  |     |
| 347  | 939  | 159  | 791  | 495   | 1087 | 125  | 1309 | 717  | 421  | 1013 | 273  | 865  | 569  | 161  | 714  | 1138  | 606  | 310  | 902  | 162  | 346  | 754  | 458  | 1058 | 88   | 1272 | 680  | 394  | 976  | 236  | 828  | 532  | 1124 | 61   | 1235 | 643  |     |
| 208  | 800  | 504  | 1096 | 134   | 1318 | 726  | 430  | 1022 | 874  | 578  | 1107 | 23   | 1207 | 615  | 319  | 911   | 173  | 1355 | 765  | 497  | 1261 | 689  | 393  | 985  | 246  | 838  | 530  | 1144 | 612  | 1244 | 652  | 356  | 948  |      |      |      |     |
| 485  | 1077 | 115  | 1299 | 707   | 411  | 1003 | 265  | 559  | 1351 | 4    | 1188 | 596  | 302  | 182  | 1366 | 744   | 488  | 1040 | 78   | 1262 | 670  | 404  | 996  | 256  | 818  | 552  | 1144 | 71   | 1255 | 663  | 367  | 959  | 219  | 811  | 515  | 107  |     |
| 145  | 1329 | 737  | 441  | 1033  | 293  | 885  | 589  | 1181 | 34   | 1318 | 626  | 330  | 922  | 182  | 1366 | 744   | 488  | 1040 | 78   | 1262 | 670  | 404  | 996  | 256  | 818  | 552  | 1144 | 71   | 1255 | 663  | 367  | 959  | 219  | 811  | 515  | 107  |     |
| 719  | 423  | 1015 | 275  | 867   | 571  | 1163 | 16   | 1200 | 608  | 314  | 904  | 164  | 1348 | 765  | 469  | 1062  | 90   | 1253 | 682  | 386  | 978  | 238  | 830  | 534  | 1246 | 658  | 1237 | 645  | 349  | 941  | 201  | 797  | 1089 | 127  | 1311 |      |     |
| 1024 | 284  | 876  | 580  | 1172  | 5    | 1209 | 617  | 321  | 913  | 173  | 1357 | 765  | 469  | 1061 | 99   | 12853 | 691  | 395  | 987  | 247  | 839  | 543  | 1135 | 62   | 1246 | 658  | 1237 | 645  | 349  | 941  | 201  | 797  | 1089 | 127  | 1311 |      |     |
| 858  | 562  | 1514 | 7    | 1191  | 599  | 303  | 895  | 155  | 1339 | 747  | 451  | 1043 | 81   | 1265 | 671  | 229   | 821  | 525  | 1117 | 44   | 1228 | 636  | 350  | 932  | 191  | 783  | 488  | 1080 | 118  | 1302 | 710  | 144  | 1066 | 266  |      |      |     |
| 1177 | 30   | 1214 | 622  | 326   | 918  | 178  | 1382 | 770  | 474  | 1066 | 104  | 1288 | 696  | 400  | 992  | 252   | 844  | 548  | 1140 | 67   | 1251 | 659  | 365  | 935  | 215  | 807  | 511  | 1103 | 141  | 1325 | 733  | 477  | 1029 | 289  | 881  | 585  |     |
| 1136 | 604  | 308  | 900  | 160   | 1344 | 752  | 456  | 1048 | 86   | 1370 | 678  | 382  | 974  | 232  | 834  | 826   | 534  | 1331 | 61   | 345  | 937  | 789  | 493  | 1082 | 404  | 132  | 1316 | 72   | 138  | 1020 | 280  | 872  | 576  | 1168 | 12   | 1205 | 613 |
| 1371 | 909  | 169  | 1353 | 761   | 465  | 1057 | 95   | 1279 | 687  | 391  | 983  | 232  | 835  | 539  | 1313 | 58    | 1242 | 650  | 346  | 206  | 798  | 502  | 1094 | 132  | 1316 | 72   | 138  | 1020 | 280  | 872  | 576  | 1168 | 12   | 1205 | 613  |      |     |
| 150  | 1334 | 742  | 446  | 1038  | 76   | 1260 | 668  | 372  | 964  | 224  | 816  | 520  | 1112 | 38   | 1223 | 631   | 335  | 927  | 187  | 483  | 1075 | 113  | 1297 | 705  | 490  | 1001 | 261  | 853  | 557  | 1149 | 598  | 1186 | 594  | 298  | 890  |      |     |
| 775  | 479  | 1071 | 109  | 1293  | 701  | 405  | 997  | 257  | 849  | 553  | 1145 | 297  | 849  | 553  | 1145 | 297   | 849  | 553  | 1145 | 297  | 849  | 553  | 1145 | 297  | 849  | 553  | 1145 | 297  | 849  | 553  | 1145 | 297  | 849  | 553  | 1145 | 297  |     |
| 1053 | 91   | 1275 | 683  | 387   | 979  | 239  | 831  | 535  | 1127 | 54   | 1238 | 646  | 350  | 942  | 202  | 794   | 498  | 1090 | 128  | 1332 | 720  | 484  | 1016 | 276  | 868  | 57   | 1164 | 17   | 1210 | 609  | 313  | 905  | 165  | 1349 | 757  | 1461 |     |
| 1284 | 692  | 396  | 988  | 248   | 544  | 1136 | 63   | 1247 | 655  | 393  | 341  | 933  | 133  | 785  | 489  | 1081  | 119  | 1303 | 711  | 415  | 1007 | 289  | 567  | 1155 | 8    | 1192 | 60   | 34   | 896  | 165  | 1340 | 748  | 452  | 1044 | 82   | 1266 | 674 |
| 273  | 845  | 549  | 1421 | 626   | 1118 | 45   | 1229 | 637  | 341  | 933  | 133  | 785  | 489  | 1081 | 119  | 1303  | 711  | 415  | 1007 | 289  | 567  | 1155 | 8    | 1192 | 60   | 34   | 896  | 165  | 1340 | 748  | 452  | 1044 | 82   | 1266 | 674  |      |     |
| 358  | 740  | 230  | 881  | 682   | 660  | 364  | 956  | 216  | 808  | 512  | 1044 | 128  | 1326 | 734  | 438  | 1030  | 290  | 882  | 586  | 1178 | 31   | 1215 | 623  | 27   | 919  | 179  | 1363 | 771  | 475  | 1067 | 105  | 1289 | 697  | 401  | 993  |      |     |
| 531  | 1123 | 651  | 1248 | 642   | 346  | 938  | 198  | 790  | 434  | 1086 | 124  | 1308 | 716  | 420  | 1084 | 124   | 1308 | 716  | 420  | 1084 | 124  | 1308 | 716  | 420  | 1084 | 124  | 1308 | 716  | 420  | 1084 | 124  | 1308 | 716  | 420  | 1084 |      |     |
| 511  | 1243 | 651  | 355  | 947   | 207  | 799  | 503  | 1095 | 133  | 1317 | 725  | 420  | 1081 | 873  | 577  | 1169  | 22   | 1206 | 614  | 318  | 910  | 170  | 1354 | 762  | 465  | 1058 | 96   | 1280 | 688  | 979  | 984  | 243  | 836  | 540  | 1132 |      |     |
| 62   | 238  | 928  | 1080 | 184   | 1076 | 14   | 1298 | 606  | 1102 | 862  | 588  | 1110 | 1189 | 439  | 1231 | 611   | 1353 | 745  | 447  | 1039 | 77   | 1261 | 669  | 373  | 965  | 245  | 747  | 113  | 40   | 1224 | 614  | 1143 | 40   | 1224 | 614  |      |     |
| 732  | 496  | 1088 | 126  | 1310  | 718  | 422  | 1014 | 79   | 1262 | 576  | 1162 | 856  | 1159 | 607  | 1111 | 903   | 163  | 1347 | 755  | 459  | 1051 | 149  | 1273 | 681  | 977  | 237  | 893  | 533  | 1125 | 552  | 544  | 940  | 200  | 800  |      |      |     |
| 732  | 496  | 1088 | 126  | 1310  | 718  | 422  | 1014 | 79   | 1262 | 576  | 1162 | 856  | 1159 | 607  | 1111 | 903   | 163  | 1347 | 755  | 459  | 1051 | 149  | 1273 | 681  | 977  | 237  | 893  | 533  | 1125 | 552  | 544  | 940  | 200  | 800  |      |      |     |
| 1307 | 135  | 119  | 727  | 431   | 1023 | 283  | 875  | 579  | 1171 | 24   | 1208 | 616  | 320  | 912  | 172  | 455   | 764  | 468  | 1062 | 68   | 1282 | 690  | 394  | 986  | 246  | 838  | 542  | 1134 | 61   | 1245 | 653  | 357  | 949  | 209  | 801  | 515  |     |
| 1300 | 708  | 412  | 1004 | 264   | 856  | 560  | 1152 | 5    | 1169 | 597  | 301  | 893  | 133  | 1337 | 745  | 449   | 1041 | 79   | 1263 | 671  | 375  | 967  | 227  | 819  | 523  | 1115 | 42   | 1226 | 634  | 338  | 930  | 700  | 782  | 488  | 1078 | 116  |     |
| 435  | 1027 | 287  | 879  | 583   | 1175 | 28   | 1212 | 620  | 898  | 136  | 1342 | 756  | 454  | 1046 | 84   | 1268  | 676  | 380  | 990  | 250  | 842  | 546  | 1134 | 657  | 361  | 953  | 213  | 805  | 509  | 101  | 130  | 1323 | 731  | 417  | 1009 |      |     |
| 259  | 861  | 565  | 157  | 11194 | 602  | 360  | 1320 | 598  | 158  | 1342 | 756  | 454  | 1046 | 84   | 1268 | 676   | 380  | 990  | 250  | 842  | 546  | 1134 | 657  | 361  | 953  | 213  | 805  | 509  | 101  | 130  | 1323 | 731  | 417  | 1009 |      |      |     |
| 574  | 1166 | 19   | 1203 | 611   | 315  | 907  | 167  | 1351 | 759  | 463  | 1055 | 93   | 1277 | 685  | 389  | 981   | 241  | 833  | 537  | 1129 | 56   | 1240 | 648  | 352  | 944  | 796  | 500  | 1092 | 130  | 1314 | 722  | 426  | 1018 | 278  | 870  |      |     |
| 0    | 1184 | 592  | 296  | 888   | 148  | 1332 | 744  | 1036 | 74   | 1258 | 666  | 370  | 962  | 222  | 844  | 518   | 1110 | 37   | 1221 | 629  | 333  | 925  | 185  | 777  | 484  | 1073 | 111  | 1292 | 601  | 1093 | 334  | 722  | 426  | 1018 | 278  | 870  |     |
| 0    | 1184 | 592  | 296  | 888   | 148  | 1332 | 744  | 1036 | 74   | 1258 | 666  | 370  | 962  | 222  | 844  | 518   | 1110 | 37   | 1221 | 629  | 333  | 925  | 185  | 777  | 484  | 1073 | 111  | 1292 | 601  | 1093 | 334  | 722  | 426  | 1018 | 278  | 870  |     |

|             |      |      |      |      |      |      |      |      |      |
|-------------|------|------|------|------|------|------|------|------|------|
| 39x39 data: |      |      |      |      |      |      |      |      |      |
| 2           | 328  | 952  | 172  | 1420 | 796  | 484  | 1108 | 94   | 1342 |
| 962         | 182  | 1430 | 806  | 494  | 1118 | 104  | 1352 | 728  | 416  |
| 1410        | 786  | 474  | 1098 | 84   | 1332 | 708  | 396  | 1020 | 240  |
| 499         | 1321 | 109  | 1357 | 733  | 421  | 1045 | 265  | 1513 | 889  |
| 893         | 1337 | 713  | 401  | 1025 | 245  | 1493 | 869  | 557  | 1181 |
| 723         | 411  | 1035 | 255  | 1503 | 879  | 567  | 1191 | 60   | 1308 |
| 1015        | 235  | 1484 | 859  | 547  | 1171 | 40   | 1288 | 664  | 352  |
| 1520        | 896  | 584  | 1208 | 77   | 1321 | 705  | 389  | 1013 | 233  |
| 565         | 1189 | 58   | 1306 | 682  | 370  | 994  | 214  | 1462 | 838  |
| 672         | 360  | 984  | 200  | 1004 | 224  | 1472 | 848  | 536  | 1160 |
| 1009        | 229  | 1477 | 853  | 541  | 1165 | 511  | 1399 | 775  | 463  |
| 1457        | 833  | 521  | 1445 | 311  | 1379 | 755  | 443  | 1067 | 287  |
| 531         | 1155 | 541  | 1389 | 765  | 433  | 1057 | 277  | 901  | 589  |
| 121         | 1369 | 748  | 403  | 1037 | 221  | 1245 | 36   | 1284 | 60   |
| 1070        | 290  | 914  | 602  | 1225 | 67   | 1265 | 641  | 329  | 953  |
| 1216        | 7    | 1235 | 631  | 319  | 943  | 163  | 1411 | 787  | 475  |
| 324         | 948  | 168  | 1416 | 792  | 480  | 1114 | 90   | 1338 | 714  |
| 178         | 1426 | 802  | 490  | 1114 | 90   | 1338 | 714  | 402  | 1026 |
| 782         | 470  | 1094 | 80   | 1328 | 704  | 392  | 1016 | 236  | 1484 |
| 1344        | 702  | 408  | 1032 | 256  | 1504 | 880  | 568  | 1192 | 61   |
| 892         | 1404 | 866  | 554  | 1178 | 47   | 1295 | 671  | 1359 | 893  |
| 241         | 579  | 1203 | 72   | 1320 | 696  | 384  | 1008 | 228  | 1476 |
| 1183        | 52   | 1300 | 676  | 364  | 988  | 208  | 1456 | 832  | 520  |
| 354         | 978  | 158  | 1446 | 822  | 510  | 1134 | 120  | 1368 | 744  |
| 834         | 522  | 1146 | 312  | 1380 | 756  | 444  | 1068 | 288  | 912  |
| 1370        | 746  | 434  | 1058 | 278  | 922  | 610  | 1223 | 649  | 337  |
| 459         | 1083 | 303  | 927  | 615  | 1239 | 30   | 1278 | 654  | 342  |
| 283         | 907  | 595  | 1219 | 10   | 1258 | 634  | 322  | 946  | 166  |
| 605         | 1229 | 20   | 1268 | 644  | 332  | 956  | 176  | 1424 | 800  |
| 0           | 1248 | 624  | 312  | 936  | 156  | 1404 | 78   | 1326 | 708  |

41x41 data:

|      |      |      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|------|------|
| 2    | 332  | 1644 | 988  | 168  | 1480 | 824  | 496  | 1152 | 86   |
| 1677 | 1021 | 1513 | 857  | 1328 | 1185 | 131  | 1431 | 775  | 447  |
| 181  | 1493 | 837  | 509  | 1165 | 99   | 1411 | 755  | 427  | 1083 |
| 847  | 513  | 1175 | 1030 | 1421 | 785  | 437  | 1093 | 235  | 1486 |
| 1426 | 70   | 442  | 1098 | 278  | 1590 | 834  | 606  | 1262 | 71   |
| 422  | 1078 | 28   | 1570 | 914  | 586  | 1242 | 53   | 1365 | 709  |
| 268  | 1580 | 924  | 596  | 1252 | 63   | 1375 | 719  | 391  | 1047 |
| 903  | 575  | 1231 | 42   | 1354 | 698  | 370  | 1026 | 206  | 1518 |
| 1373 | 717  | 388  | 1046 | 225  | 1337 | 881  | 855  | 1209 | 613  |
| 398  | 1055 | 23   | 1547 | 931  | 563  | 1129 | 133  | 1445 | 809  |
| 213  | 1527 | 871  | 543  | 1199 | 133  | 1445 | 789  | 461  | 1137 |
| 896  | 568  | 1224 | 58   | 1470 | 814  | 486  | 1142 | 322  | 1634 |
| 1460 | 804  | 471  | 1131 | 1024 | 866  | 640  | 1296 | 26   | 1337 |
| 456  | 1131 | 293  | 1604 | 948  | 620  | 1276 | 5    | 1317 | 661  |
| 325  | 1637 | 981  | 653  | 1309 | 38   | 1350 | 694  | 366  | 1678 |
| 961  | 633  | 1289 | 38   | 1330 | 674  | 346  | 1658 | 1002 | 482  |
| 1239 | 646  | 1307 | 684  | 358  | 1395 | 1002 | 482  | 1004 | 224  |
| 361  | 1673 | 1017 | 1509 | 853  | 525  | 1181 | 115  | 1427 | 771  |
| 997  | 177  | 1489 | 833  | 505  | 1141 | 95   | 1407 | 751  | 427  |
| 1499 | 843  | 513  | 1171 | 1005 | 1417 | 961  | 1433 | 1089 | 269  |
| 434  | 1350 | 84   | 1396 | 740  | 421  | 1068 | 448  | 1206 | 934  |
| 757  | 423  | 1085 | 265  | 1577 | 921  | 993  | 1249 | 60   | 1372 |
| 1095 | 275  | 1587 | 931  | 532  | 1062 | 706  | 1382 | 728  | 416  |
| 1368 | 1244 | 73   | 1387 | 711  | 403  | 1059 | 239  | 1551 | 895  |
| 608  | 1264 | 75   | 1387 | 711  | 403  | 1059 | 239  | 1551 | 895  |
| 721  | 393  | 1049 | 231  | 1584 | 885  | 357  | 1213 | 1407 | 1459 |
| 1028 | 208  | 1580 | 924  | 596  | 1252 | 63   | 1375 | 719  | 391  |
| 1353 | 897  | 569  | 1225 | 556  | 1471 | 815  | 1487 | 1143 | 323  |
| 540  | 1205 | 139  | 1453 | 755  | 467  | 1123 | 303  | 1615 | 959  |
| 785  | 467  | 1113 | 293  | 1608 | 948  | 621  | 1277 | 6    | 1318 |
| 1138 | 138  | 1630 | 924  | 61   | 1323 | 67   | 1343 | 867  | 511  |
| 1610 | 954  | 1626 | 1282 | 11   | 1323 | 67   | 1343 | 867  | 511  |
| 636  | 1232 | 656  | 328  | 1460 | 984  | 161  | 1005 | 188  | 1497 |
| 0    | 1312 | 636  | 328  | 1460 | 984  | 161  | 1005 | 188  | 1497 |

## 43x43 data:

|      |      |      |      |     |     |      |     |      |     |      |      |      |      |      |     |     |      |    |      |    |     |      |      |     |     |     |     |      |     |      |     |     |      |     |      |     |      |    |      |     |     |
|------|------|------|------|-----|-----|------|-----|------|-----|------|------|------|------|------|-----|-----|------|----|------|----|-----|------|------|-----|-----|-----|-----|------|-----|------|-----|-----|------|-----|------|-----|------|----|------|-----|-----|
| 2    | 359  | 1735 | 1057 | 847 | 562 | 1230 | 51  | 1219 | 101 | 1477 | 789  | 445  | 1284 | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 | 230 | 586 | 918 | 574 | 1262 | 144 | 1520 | 882 | 488 | 1176 | 302 | 1065 | 974 | 1359 | 26 | 1402 | 714 | 370 |
| 1746 | 1058 | 138  | 1574 | 886 | 542 | 1230 | 112 | 1488 | 80  | 456  | 1832 | 1144 | 284  | 1660 | 971 | 617 | 1305 | 58 | 1434 | 46 | 402 | 1778 | 1090 |     |     |     |     |      |     |      |     |     |      |     |      |     |      |    |      |     |     |

**45x45 data:**

|      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 2    | 370  | 3810 | 190  | 350  | 910  | 500  | 1390 | 1270 | 100  | 1540 | 820  | 460  | 1300 | 280  | 1720 | 1000 | 640  | 1330 | 855  | 1495 | 75   | 415  | 165  | 103  | 235  | 1675 | 955  | 135  | 145  | 1595 | 125  | 1395 | 125  | 325  | 1765 | 1045 | 685  | 1405 |      |
| 1838 | 118  | 218  | 1658 | 398  | 578  | 210  | 1298 | 128  | 1568 | 848  | 498  | 1928 | 108  | 3748 | 1028 | 1760 | 1000 | 540  | 1330 | 855  | 1495 | 75   | 415  | 165  | 103  | 235  | 1675 | 955  | 135  | 145  | 1595 | 125  | 1395 | 125  | 325  | 1765 | 1045 | 685  | 1405 |
| 1936 | 565  | 916  | 556  | 1956 | 1276 | 106  | 1546 | 826  | 466  | 1906 | 1186 | 286  | 1736 | 606  | 1356 | 61   | 1501 | 781  | 421  | 1861 | 1411 | 241  | 1681 | 961  | 151  | 581  | 1931 | 321  | 1771 | 1051 | 691  | 141  | 16   | 1456 | 736  | 376  | 1816 | 1006 |      |
| 927  | 567  | 2007 | 1287 | 117  | 1357 | 807  | 437  | 1937 | 1197 | 657  | 1037 | 727  | 1377 | 627  | 1057 | 732  | 427  | 1872 | 1152 | 2592 | 922  | 1612 | 982  | 1232 | 1562 | 882  | 1922 | 1322 | 1782 | 1022 | 742  | 27   | 1467 | 747  | 387  | 1827 | 1017 |      |      |
| 1371 | 851  | 491  | 1391 | 231  | 1751 | 331  | 1751 | 331  | 671  | 336  | 6526 | 86   | 1446 | 1886 | 166  | 2706 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   | 1616 | 96   |
| 829  | 469  | 1059 | 1189 | 289  | 1729 | 1039 | 439  | 1369 | 64   | 1504 | 784  | 424  | 1864 | 144  | 2684 | 964  | 1324 | 1594 | 874  | 5194 | 324  | 1374 | 1054 | 694  | 144  | 1459 | 739  | 379  | 1819 | 1099 | 1639 | 519  | 559  | 1399 | 1279 | 1059 | 1349 |      |      |
| 1320 | 1200 | 300  | 1740 | 1020 | 60   | 1380 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   | 1515 | 75   |
| 27   | 3717 | 907  | 3357 | 85   | 1492 | 772  | 412  | 1852 | 1312 | 2275 | 1675 | 925  | 1382 | 142  | 1582 | 162  | 1042 | 122  | 1762 | 1042 | 642  | 1462 | 972  | 1467 | 357  | 1087 | 1827 | 907  | 547  | 1987 | 1267 | 97   | 1537 | 817  | 457  | 1897 | 1177 |      |      |
| 1603 | 488  | 78   | 4188 | 1858 | 138  | 678  | 369  | 1588 | 598  | 1338 | 148  | 1588 | 608  | 1228 | 1768 | 1068 | 688  | 1408 | 738  | 3738 | 1813 | 1293 | 653  | 1353 | 583  | 1923 | 1073 | 613  | 1453 | 823  | 1043 | 1543 | 823  | 1043 | 1543 | 823  | 1043 | 1543 |      |
| 1509 | 789  | 428  | 1869 | 1149 | 249  | 1689 | 969  | 339  | 1329 | 579  | 1559 | 879  | 519  | 1359 | 1239 | 339  | 1779 | 1059 | 649  | 1449 | 749  | 3849 | 1824 | 949  | 1464 | 749  | 3849 | 1824 | 949  | 1464 | 749  | 3849 | 1824 | 949  | 1464 | 749  | 3849 | 1824 |      |
| 400  | 1846 | 1126 | 226  | 1666 | 94   | 586  | 1306 | 316  | 1576 | 866  | 436  | 1216 | 316  | 1576 | 866  | 436  | 1216 | 316  | 1576 | 866  | 436  | 1216 | 316  | 1576 | 866  | 436  | 1216 | 316  | 1576 | 866  | 436  | 1216 | 316  | 1576 | 866  | 436  | 1216 | 316  |      |
| 1169 | 269  | 989  | 629  | 1349 | 779  | 1619 | 839  | 379  | 1259 | 539  | 1779 | 979  | 719  | 1439 | 474  | 1484 | 184  | 1844 | 124  | 1644 | 104  | 1844 | 124  | 1644 | 104  | 1844 | 124  | 1644 | 104  | 1844 | 124  | 1644 | 104  | 1844 | 124  | 1644 | 104  | 1844 | 124  |
| 1603 | 488  | 78   | 4188 | 1858 | 138  | 678  | 369  | 1588 | 598  | 1338 | 148  | 15   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

**47x47 data:**

|   |      |      |      |      |      |      |      |      |      |      |      |      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |    |    |    |    |    |   |    |     |     |     |     |     |     |     |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |     |
|---|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|---|----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|
| 1 | 1394 | 1134 | 1112 | 1100 | 1088 | 1076 | 1064 | 1052 | 1040 | 1028 | 1016 | 1004 | 992 | 980 | 968 | 956 | 944 | 932 | 920 | 908 | 896 | 884 | 872 | 860 | 848 | 836 | 824 | 812 | 800 | 788 | 776 | 764 | 752 | 740 | 728 | 716 | 704 | 692 | 680 | 668 | 656 | 644 | 632 | 620 | 608 | 596 | 584 | 572 | 560 | 548 | 536 | 524 | 512 | 500 | 488 | 476 | 464 | 452 | 440 | 428 | 416 | 404 | 392 | 380 | 368 | 356 | 344 | 332 | 320 | 308 | 296 | 284 | 272 | 260 | 248 | 236 | 224 | 212 | 200 | 188 | 176 | 164 | 152 | 140 | 128 | 116 | 104 | 92 | 80 | 68 | 56 | 44 | 32 | 20 | 8 | -4 | -16 | -28 | -40 | -52 | -64 | -76 | -88 | -100 | -112 | -124 | -136 | -148 | -160 | -172 | -184 | -196 | -208 | -220 | -232 | -244 | -256 | -268 | -280 | -292 | -304 | -316 | -328 | -340 | -352 | -364 | -376 | -388 | -400 | -412 | -424 | -436 | -448 | -460 | -472 | -484 | -496 | -508 | -520 | -532 | -544 | -556 | -568 | -580 | -592 | -604 | -616 | -628 | -640 | -652 | -664 | -676 | -688 | -700 | -712 | -724 | -736 | -748 | -760 | -772 | -784 | -796 | -808 | -820 | -832 | -844 | -856 | -868 | -880 | -892 | -904 | -916 | -928 | -940 | -952 | -964 | -976 | -988 | -1000 | -1012 | -1024 | -1036 | -1048 | -1060 | -1072 | -1084 | -1096 | -1108 | -1120 | -1132 | -1144 | -1156 | -1168 | -1180 | -1192 | -1204 | -1216 | -1228 | -1240 | -1252 | -1264 | -1276 | -1288 | -1300 | -1312 | -1324 | -1336 | -1348 | -1360 | -1372 | -1384 | -1396 | -1408 | -1420 | -1432 | -1444 | -1456 | -1468 | -1480 | -1492 | -1504 | -1516 | -1528 | -1540 | -1552 | -1564 | -1576 | -1588 | -1600 | -1612 | -1624 | -1636 | -1648 | -1660 | -1672 | -1684 | -1696 | -1708 | -1720 | -1732 | -1744 | -1756 | -1768 | -1780 | -1792 | -1804 | -1816 | -1828 | -1840 | -1852 | -1864 | -1876 | -1888 | -1900 | -1912 | -1924 | -1936 | -1948 | -1960 | -1972 | -1984 | -1996 | -2008 | -2020 | -2032 | -2044 | -2056 | -2068 | -2080 | -2092 | -2104 | -2116 | -2128 | -2140 | -2152 | -2164 | -2176 | -2188 | -2200 | -2212 | -2224 | -2236 | -2248 | -2260 | -2272 | -2284 | -2296 | -2308 | -2320 | -2332 | -2344 | -2356 | -2368 | -2380 | -2392 | -2404 | -2416 | -2428 | -2440 | -2452 | -2464 | -2476 | -2488 | -2500 | -2512 | -2524 | -2536 | -2548 | -2560 | -2572 | -2584 | -2596 | -2608 | -2620 | -2632 | -2644 | -2656 | -2668 | -2680 | -2692 | -2704 | -2716 | -2728 | -2740 | -2752 | -2764 | -2776 | -2788 | -2800 | -2812 | -2824 | -2836 | -2848 | -2860 | -2872 | -2884 | -2896 | -2908 | -2920 | -2932 | -2944 | -2956 | -2968 | -2980 | -2992 | -3004 | -3016 | -3028 | -3040 | -3052 | -3064 | -3076 | -3088 | -3100 | -3112 | -3124 | -3136 | -3148 | -3160 | -3172 | -3184 | -3196 | -3208 | -3220 | -3232 | -3244 | -3256 | -3268 | -3280 | -3292 | -3304 | -3316 | -3328 | -3340 | -3352 | -3364 | -3376 | -3388 | -3400 | -3412 | -3424 | -3436 | -3448 | -3460 | -3472 | -3484 | -3496 | -3508 | -3520 | -3532 | -3544 | -3556 | -3568 | -3580 | -3592 | -3604 | -3616 | -3628 | -3640 | -3652 | -3664 | -3676 | -3688 | -3700 | -3712 | -3724 | -3736 | -3748 | -3760 | -3772 | -3784 | -3796 | -3808 | -3820 | -3832 | -3844 | -3856 | -3868 | -3880 | -3892 | -3904 | -3916 | -3928 | -3940 | -3952 | -3964 | -3976 | -3988 | -4000 | -4012 | -4024 | -4036 | -4048 | -4060 | -4072 | -4084 | -4096 | -4108 | -4120 | -4132 | -4144 | -4156 | -4168 | -4180 | -4192 | -4204 | -4216 | -4228 | -4240 | -4252 | -4264 | -4276 | -4288 | -4300 | -4312 | -4324 | -4336 | -4348 | -4360 | -4372 | -4384 | -4396 | -4408 | -4420 | -4432 | -4444 | -4456 | -4468 | -4480 | -4492 | -4504 | -4516 | -4528 | -4540 | -45 |
|---|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|---|----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|

## Annexe C (Normative)

### ECC 000 - 140 Character Encodation Schemes

This Annexe provides details of the ASCII character set (ANSI X3.4) used for one of the ECC 000-140 encodation schemes, and the four encodation schemes showing the mapping of the data character to the encodation scheme code value.

| ASCII SET |               | ENCODATION SCHEME  |                    |                    |                    |
|-----------|---------------|--------------------|--------------------|--------------------|--------------------|
| Character | Decimal Value | Base 11 Code Value | Base 27 Code Value | Base 37 Code Value | Base 41 Code Value |
| NUL       | 0             |                    |                    |                    |                    |
| SOH       | 1             |                    |                    |                    |                    |
| STX       | 2             |                    |                    |                    |                    |
| ETX       | 3             |                    |                    |                    |                    |
| EOT       | 4             |                    |                    |                    |                    |
| ENQ       | 5             |                    |                    |                    |                    |
| ACK       | 6             |                    |                    |                    |                    |
| BEL       | 7             |                    |                    |                    |                    |
| BS        | 8             |                    |                    |                    |                    |
| HT        | 9             |                    |                    |                    |                    |
| LF        | 10            |                    |                    |                    |                    |
| VT        | 11            |                    |                    |                    |                    |
| FF        | 12            |                    |                    |                    |                    |
| CR        | 13            |                    |                    |                    |                    |
| SO        | 14            |                    |                    |                    |                    |
| SI        | 15            |                    |                    |                    |                    |
| DLE       | 16            |                    |                    |                    |                    |
| DC1       | 17            |                    |                    |                    |                    |
| DC2       | 18            |                    |                    |                    |                    |
| DC3       | 19            |                    |                    |                    |                    |
| DC4       | 20            |                    |                    |                    |                    |
| NAK       | 21            |                    |                    |                    |                    |
| SYN       | 22            |                    |                    |                    |                    |
| ETB       | 23            |                    |                    |                    |                    |
| CAN       | 24            |                    |                    |                    |                    |
| EM        | 25            |                    |                    |                    |                    |
| SUB       | 26            |                    |                    |                    |                    |
| ESC       | 27            |                    |                    |                    |                    |
| FS        | 28            |                    |                    |                    |                    |
| GS        | 29            |                    |                    |                    |                    |
| RS        | 30            |                    |                    |                    |                    |
| US        | 31            |                    |                    |                    |                    |
| space     | 32            | 0                  | 0                  | 0                  | 0                  |
| !         | 33            |                    |                    |                    |                    |
| "         | 34            |                    |                    |                    |                    |
| #         | 35            |                    |                    |                    |                    |
| \$        | 36            |                    |                    |                    |                    |
| %         | 37            |                    |                    |                    |                    |

**Table C1: Mapping of Data Character Value to Encodation Scheme Value**

| ASCII SET |               | ENCODATION SCHEME  |                    |                    |                    |
|-----------|---------------|--------------------|--------------------|--------------------|--------------------|
| Character | Decimal Value | Base 11 Code Value | Base 27 Code Value | Base 37 Code Value | Base 41 Code Value |
| &         | 38            |                    |                    |                    |                    |
| '         | 39            |                    |                    |                    |                    |
| (         | 40            |                    |                    |                    |                    |
| )         | 41            |                    |                    |                    |                    |
| *         | 42            |                    |                    |                    |                    |
| +         | 43            |                    |                    |                    |                    |
| ,         | 44            |                    |                    |                    |                    |
| -         | 45            |                    |                    |                    | 38                 |
| .         | 46            |                    |                    |                    | 39                 |
| /         | 47            |                    |                    |                    | 37                 |
| 0         | 48            | 1                  |                    | 27                 | 40                 |
| 1         | 49            | 2                  |                    | 28                 | 27                 |
| 2         | 50            | 3                  |                    | 29                 | 28                 |
| 3         | 51            | 4                  |                    | 30                 | 29                 |
| 4         | 52            | 5                  |                    | 31                 | 30                 |
| 5         | 53            | 6                  |                    | 32                 | 31                 |
| 6         | 54            | 7                  |                    | 33                 | 32                 |
| 7         | 55            | 8                  |                    | 34                 | 33                 |
| 8         | 56            | 9                  |                    | 35                 | 34                 |
| 9         | 57            | 10                 |                    | 36                 | 35                 |
| :         | 58            |                    |                    |                    | 36                 |
| ;         | 59            |                    |                    |                    |                    |
| <         | 60            |                    |                    |                    |                    |
| =         | 61            |                    |                    |                    |                    |
| >         | 62            |                    |                    |                    |                    |
| ?         | 63            |                    |                    |                    |                    |
| @         | 64            |                    |                    |                    |                    |
| A         | 65            |                    | 1                  | 1                  | 1                  |
| B         | 66            |                    | 2                  | 2                  | 2                  |
| C         | 67            |                    | 3                  | 3                  | 3                  |
| D         | 68            |                    | 4                  | 4                  | 4                  |
| E         | 69            |                    | 5                  | 5                  | 5                  |
| F         | 70            |                    | 6                  | 6                  | 6                  |
| G         | 71            |                    | 7                  | 7                  | 7                  |
| H         | 72            |                    | 8                  | 8                  | 8                  |
| I         | 73            |                    | 9                  | 9                  | 9                  |
| J         | 74            |                    | 10                 | 10                 | 10                 |
| K         | 75            |                    | 11                 | 11                 | 11                 |
| L         | 76            |                    | 12                 | 12                 | 12                 |
| M         | 77            |                    | 13                 | 13                 | 13                 |
| N         | 78            |                    | 14                 | 14                 | 14                 |
| O         | 79            |                    | 15                 | 15                 | 15                 |
| P         | 80            |                    | 16                 | 16                 | 16                 |
| Q         | 81            |                    | 17                 | 17                 | 17                 |
| R         | 82            |                    | 18                 | 18                 | 18                 |
| S         | 83            |                    | 19                 | 19                 | 19                 |

Table C1: Mapping of Data Character Value to Encodation Scheme Value (Continued.)

| ASCII SET |               | ENCODATION SCHEME  |                    |                    |                    |
|-----------|---------------|--------------------|--------------------|--------------------|--------------------|
| Character | Decimal Value | Base 11 Code Value | Base 27 Code Value | Base 37 Code Value | Base 41 Code Value |
| T         | 84            |                    | 20                 | 20                 | 20                 |
| U         | 85            |                    | 21                 | 21                 | 21                 |
| V         | 86            |                    | 22                 | 22                 | 22                 |
| W         | 87            |                    | 23                 | 23                 | 23                 |
| X         | 88            |                    | 24                 | 24                 | 24                 |
| Y         | 89            |                    | 25                 | 25                 | 25                 |
| Z         | 90            |                    | 26                 | 26                 | 26                 |
| [         | 91            |                    |                    |                    |                    |
| \         | 92            |                    |                    |                    |                    |
| ]         | 93            |                    |                    |                    |                    |
| ^         | 94            |                    |                    |                    |                    |
| -         | 95            |                    |                    |                    |                    |
| '         | 96            |                    |                    |                    |                    |
| a         | 97            |                    |                    |                    |                    |
| b         | 98            |                    |                    |                    |                    |
| c         | 99            |                    |                    |                    |                    |
| d         | 100           |                    |                    |                    |                    |
| e         | 101           |                    |                    |                    |                    |
| f         | 102           |                    |                    |                    |                    |
| g         | 103           |                    |                    |                    |                    |
| h         | 104           |                    |                    |                    |                    |
| i         | 105           |                    |                    |                    |                    |
| j         | 106           |                    |                    |                    |                    |
| k         | 107           |                    |                    |                    |                    |
| l         | 108           |                    |                    |                    |                    |
| m         | 109           |                    |                    |                    |                    |
| n         | 110           |                    |                    |                    |                    |
| o         | 111           |                    |                    |                    |                    |
| p         | 112           |                    |                    |                    |                    |
| q         | 113           |                    |                    |                    |                    |
| r         | 114           |                    |                    |                    |                    |
| s         | 115           |                    |                    |                    |                    |
| t         | 116           |                    |                    |                    |                    |
| u         | 117           |                    |                    |                    |                    |
| v         | 118           |                    |                    |                    |                    |
| w         | 119           |                    |                    |                    |                    |
| x         | 120           |                    |                    |                    |                    |
| y         | 121           |                    |                    |                    |                    |
| z         | 122           |                    |                    |                    |                    |
| {         | 123           |                    |                    |                    |                    |
|           | 124           |                    |                    |                    |                    |
| }         | 125           |                    |                    |                    |                    |
| ~         | 126           |                    |                    |                    |                    |
| DEL       | 127           |                    |                    |                    |                    |

Table C1: Mapping of Data Character Value to Encodation Scheme Value (Concluded)

C.1 Base 11 Encodation Scheme

C.1.1 First Stage Procedure

The data characters shall be converted to their Base 11 code values using Table C1 as the conversion table.

C.1.2 Second Stage Procedure

The following procedure shall be used to compact the Base 11 code values to a binary string.

- 1. Sub-divide the number of Base 11 characters into a sequence of six characters, from left to right. If less than six characters go to Step 5.
- 2. Assign the code values of the six Base 11 characters as  $C_1$  to  $C_6$ , where  $C_1$  is the first character.
- 3. Carry out a Base 11 to Base 2 conversion to produce a sequence of 21 bits, using equation 6 of Table C2.

- 4. Repeat from Step 1 as necessary.
- 5. When there are less than six characters, carry out a Base 11 to Base 2 conversion using the appropriate equation of Table C2 which is equal to the number of remaining Base 11 characters.

C.1.3 Example

Using the data character string:

123 45678

the complete Base 11 encodation process is shown in Figure C1.

| Number of Data Characters | Encodation Equation                              | Bit Length |
|---------------------------|--------------------------------------------------|------------|
| 1                         | $C_1$                                            | 4          |
| 2                         | $C_1+C_2*11$                                     | 7          |
| 3                         | $C_1+C_2*11+C_3*11^2$                            | 11         |
| 4                         | $C_1+C_2*11+C_3*11^2+C_4*11^3$                   | 14         |
| 5                         | $C_1+C_2*11+C_3*11^2+C_4*11^3+C_5*11^4$          | 18         |
| 6                         | $C_1+C_2*11+C_3*11^2+C_4*11^3+C_5*11^4+C_6*11^5$ | 21         |

Table C2: Base 11 (Numeric) Encodation Equations

|                    |                       |       |       |       |       |             |       |       |
|--------------------|-----------------------|-------|-------|-------|-------|-------------|-------|-------|
| Data               | 1                     | 2     | 3     | 4     | 5     | 6           | 7     | 8     |
| Base 11 code value | 2                     | 3     | 4     | 0     | 5     | 6           | 7     | 8     |
| Character position | $C_1$                 | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_6$       | $C_1$ | $C_2$ |
| Decimal value      | 1040030               |       |       |       |       | 1184        |       |       |
| Binary string      | 011111101111010011110 |       |       |       |       | 10010100000 |       |       |

Figure C1: Base 11 Example

## C.2 Base 27 Encodation Scheme

### C.2.1 First Stage Procedure

The data characters shall be converted to their Base 27 code values using Table C1 as the conversion table.

### C.2.2 Second Stage Procedure

The following procedure shall be used to compact the Base 27 code values to a binary string.

1. Sub-divide the number of Base 27 characters into a sequence of five characters, from left to right. If less than five characters go to Step 5.
2. Assign the code values of the five Base 27 characters as  $C_1$  to  $C_5$ , where  $C_1$  is the first character.

3. Carry out a Base 27 to Base 2 conversion to produce a sequence of 24 bits, using equation 5 of Table C3.

4. Repeat from Step 1 as necessary.

5. When there are less than five characters, carry out a Base 27 to Base 2 conversion using the appropriate equation of Table C3 which is equal to the number of remaining Base 27 characters.

### C.2.3 Example

Using the data character string:

DATA MATRIX

the complete Base 27 encodation process is shown in Figure C2.

| Number of Data Characters | Encodation Equation                                     | Bit Length |
|---------------------------|---------------------------------------------------------|------------|
| 1                         | $C_1$                                                   | 5          |
| 2                         | $C_1 + C_2 * 27$                                        | 10         |
| 3                         | $C_1 + C_2 * 27 + C_3 * 27^2$                           | 15         |
| 4                         | $C_1 + C_2 * 27 + C_3 * 27^2 + C_4 * 27^3$              | 20         |
| 5                         | $C_1 + C_2 * 27 + C_3 * 27^2 + C_4 * 27^3 + C_5 * 27^4$ | 24         |

**Table C3: Base 27 (Upper-case Alphabetic) Encodation Equations**

|                    |                          |       |       |       |       |                          |       |       |       |       |       |
|--------------------|--------------------------|-------|-------|-------|-------|--------------------------|-------|-------|-------|-------|-------|
| Data               | D                        | A     | T     | A     |       | M                        | A     | T     | R     | I     | X     |
| Base 27 code value | 4                        | 1     | 20    | 1     | 0     | 13                       | 1     | 20    | 18    | 9     | 24    |
| Character position | $C_1$                    | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_1$                    | $C_2$ | $C_3$ | $C_4$ | $C_5$ | $C_1$ |
| Decimal value      | 34294                    |       |       |       |       | 5151883                  |       |       |       |       | 24    |
| Binary string      | 000000001000010111110110 |       |       |       |       | 010011101001110010001011 |       |       |       |       | 11000 |

**Figure C2: Base 27 Example**

C.3 Base 37 Encodation Scheme

C.3.1 First Stage Procedure

The data characters shall be converted to their Base 37 code values using Table C1 as the conversion table.

C.3.2 Second Stage Procedure

The following procedure shall be used to compact the Base 37 code values to a binary string.

- 1. Sub-divide the number of Base 37 characters into a sequence of four characters, from left to right. If less than four characters go to Step 5.
- 2. Assign the code values of the four Base 37 characters as  $C_1$  to  $C_4$ , where  $C_1$  is the first character.
- 3. Carry out a Base 37 to Base 2 conversion to produce a sequence of 21 bits, using equation 4 of Table C4.

- 4. Repeat from Step 1 as necessary.
- 5. When there are less than four characters, carry out a Base 37 to Base 2 conversion using the equation (1 to 3) of Table C4 which is equal to the number of remaining Base 37 characters.

C.3.3 Example

Using the data character string:

123ABCD89

the complete Base 37 encodation process is shown in Figure C3.

| Number of Data Characters | Encodation Equation                        | Bit Length |
|---------------------------|--------------------------------------------|------------|
| 1                         | $C_1$                                      | 6          |
| 2                         | $C_1 + C_2 * 37$                           | 11         |
| 3                         | $C_1 + C_2 * 37 + C_3 * 37^2$              | 16         |
| 4                         | $C_1 + C_2 * 37 + C_3 * 37^2 + C_4 * 37^3$ | 21         |

Table C4: Base 37 (Upper-case Alphanumeric) Encodation Equations

|                    |                       |       |       |       |                       |       |       |       |        |
|--------------------|-----------------------|-------|-------|-------|-----------------------|-------|-------|-------|--------|
| Data               | 1                     | 2     | 3     | A     | B                     | C     | D     | 8     | 9      |
| Base 37 code value | 28                    | 29    | 30    | 1     | 2                     | 3     | 4     | 35    | 36     |
| Character position | $C_1$                 | $C_2$ | $C_3$ | $C_4$ | $C_1$                 | $C_2$ | $C_3$ | $C_4$ | $C_1$  |
| Decimal value      | 92824                 |       |       |       | 1778444               |       |       |       | 36     |
| Binary string      | 000010110101010011000 |       |       |       | 110110010001100001100 |       |       |       | 100100 |

Figure C3: Base 37 Example

## C.4 Base 41 Encodation Scheme

### C.4.1 First Stage Procedure

The data characters shall be converted to their Base 41 code values using Table C1 as the conversion table.

### C.4.2 Second Stage Procedure

The following procedure shall be used to compact the Base 41 code values to a binary string.

1. Sub-divide the number of Base 41 characters into a sequence of four characters, from left to right. If less than four characters go to Step 5.
2. Assign the code values of the four Base 41 characters as  $C_1$  to  $C_4$ , where  $C_1$  is the first character.
3. Carry out a Base 41 to Base 2 conversion to produce a sequence of 22 bits, using equation 4 of Table C5.

4. Repeat from Step 1 as necessary.

5. When there are less than four characters, carry out a Base 41 to Base 2 conversion using the appropriate equation of Table C5 which is equal to the number of remaining Base 41 characters.

### C.4.3 Example

Using the data character string:

**AB/C123-X**

the complete Base 41 encodation process is shown in Figure C4.

| Number of Data Characters | Encodation Equation                        | Bit Length |
|---------------------------|--------------------------------------------|------------|
| 1                         | $C_1$                                      | 6          |
| 2                         | $C_1 + C_2 * 41$                           | 11         |
| 3                         | $C_1 + C_2 * 41 + C_3 * 41^2$              | 17         |
| 4                         | $C_1 + C_2 * 41 + C_3 * 41^2 + C_4 * 41^3$ | 22         |

**Table C5: Base 41 (Upper-case Alphanumeric + Punctuation) Encodation Equations**

|                    |                        |        |       |       |                        |       |       |       |        |
|--------------------|------------------------|--------|-------|-------|------------------------|-------|-------|-------|--------|
| Data               | A                      | B      | /     | C     | 1                      | 2     | 3     | -     | X      |
| Base 41 code value | 1                      | 2      | 40    | 3     | 28                     | 29    | 30    | 39    | 24     |
| Character position | $C_1$                  | $C_2$  | $C_3$ | $C_4$ | $C_1$                  | $C_2$ | $C_3$ | $C_4$ | $C_1$  |
| Decimal value      |                        | 274086 |       |       | 2739566                |       |       |       | 24     |
| Binary string      | 0001000010111010100110 |        |       |       | 1010011100110101101110 |       |       |       | 011000 |

**Figure C4: Base 41 Example**

Annexe D (Normative)

ECC 000 - 140 CRC Algorithm

Following are two implementations for representing CRC.

D.1 CRC State Machine

The CRC may be represented as a schematic, as illustrated in Figure D1. After the data bits have been shifted throught the state machine the resulting CRC is read out of the 16 memory registers (m) in the diagram (left most register is the MSB).

D.2 CRC Polynomial

The CRC algorithm shall be the CCITT standard polynomial:

$X^{16}+X^{12}+X^5+1$

With X equals 2, the value of the polynomial shown as a 17 bit value is:

$10001000000100001_{base\ 2}$

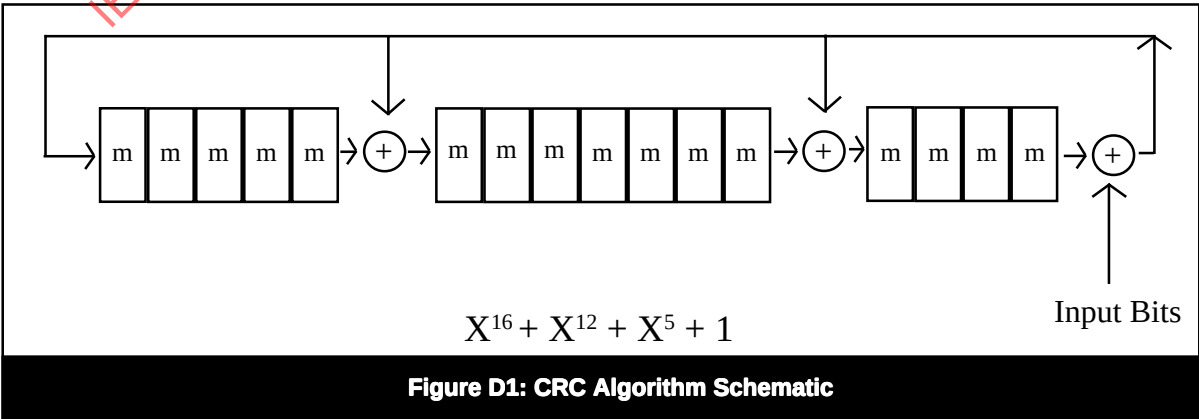
The CRC is the remainder after dividing the data string by this value.

D.3 CRC 2-Byte Header

The CRC Calculation Headers, as defined in Table D1, are used in the CRC operation as a prefix to the 8-bit byte values of the data characters. The CRC 2-byte header is shifted into the state machine prior to the calculation of the CRC.

| Format ID | Encodation Scheme | CRC Calculation Header |          |       |
|-----------|-------------------|------------------------|----------|-------|
|           |                   | MS Byte                | LS Byte  | Hex   |
| 1         | Base 11           | 00000001               | 00000000 | 01 00 |
| 2         | Base 27           | 00000010               | 00000000 | 02 00 |
| 3         | Base 41           | 00000011               | 00000000 | 03 00 |
| 4         | Base 37           | 00000100               | 00000000 | 04 00 |
| 5         | ASCII             | 00000101               | 00000000 | 05 00 |
| 6         | 8-bit Byte        | 00000110               | 00000000 | 06 00 |

Table D1: CRC Calculation Header



## Annexe E (Normative)

### ECC 000 - 140 Error Checking and Correcting Algorithms

#### E.1 ECC 000

This provides no error correction.

#### E.2 ECC 050

The error correction bit stream 'v' for ECC 050 shall be created by processing the user data bit stream 'u' through a state machine suitable for a convolutional code of the structure 4-3-3, as illustrated in Figure E1.

#### E.3 ECC 080

The error correction bit stream 'v' for ECC 080 shall be created by processing the user bit stream 'u' through a state machine suitable for a convolutional code of the structure 3-2-11, as illustrated in Figure E2.

#### E.4 ECC 100

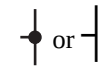
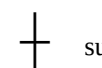
The error correction bit stream 'v' for ECC 100 shall be created by processing the user bit stream 'u' through a state machine suitable for a convolutional code of the structure 2-1-15, as illustrated in Figure E3.

#### E.5 ECC 140

The error correction bit stream 'v' for ECC 140 shall be created by processing the user bit stream 'u' through a state machine suitable for a convolutional code of the structure 4-1-13, as illustrated in Figure E4.

#### E.6 Processing the Convolutional Code

In the state machine circuit diagrams, the following notation is used:

-  represents a single bit storage register
-  represents a one bit binary adder which outputs the lowest bit. It is equivalent to an odd parity generator.
-  or  such adjoining lines are connected
-  such intersecting lines are not connected

The state machine is operated as follows:

1. The memory storage registers (m) are filled with a zero value before starting the process.
2. An input cycle is performed, consisting of passing a user data bit through the input switch to a memory storage register (m) for each possible input switch position, i.e. for k bits.
3. Once a complete set of k input bits has been entered, an output cycle is performed. An output cycle consists of reading out an error corrected bit for each possible output switch position, i.e. for n bits. At each position, the output bit is computed by performing an XOR operation on the connected memory storage register values.
4. After one input and output cycle, a shift operation is performed by shifting all memory storage register values to the right by one position.
5. Steps 2 through 4 are repeated until all raw data bits have been input. At the end:
  - a. Some zero bits may need to be added to the end of the last segment of input bits to ensure that k bits are input.
  - b. Sufficient additional zero bits shall be input to ensure that the m memory storage registers shall all return to zero values.

The output from Steps 5a and 5b is part of the encoded data. The process is complete when all true data bits have passed through the last (rightmost) memory storage register.

#### E.7 Convolutional Codes Reference Decode Algorithm

The Fano algorithm can be used for error correction of data protected by convolutional codes. A basic description of the operation of the Fano algorithm is given in Lin and Costello (see Reference below). The following guidelines should be used in constructing a convolutional coding decoder.

The startup variable values must be as follows:

Backward Metric = maximum negative number  
 Current Metric = 0  
 Forward Metric = 0  
 Threshold = 0

The metric is computed by determining the number of bits that are different between the damaged block and the candidate match block:

$$\text{Metric} = (1 * \text{correct bits}) - (\text{penalty} * \text{incorrect})$$

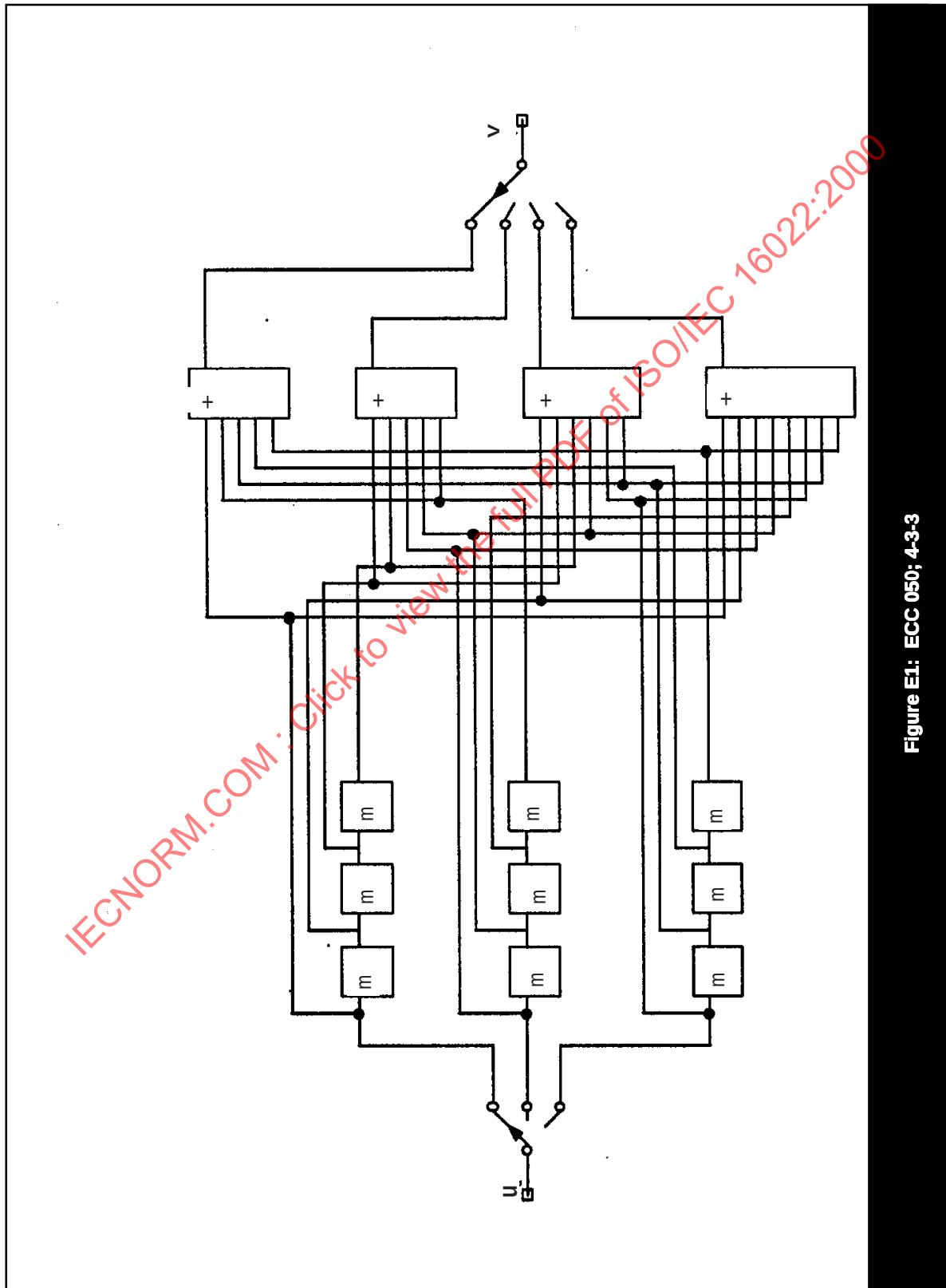
Table E1 presents values for the Single Bit Penalty and Delta which should be used when decoding each of the ECC levels.

| ECC Level | Single Bit Penalty | Delta |
|-----------|--------------------|-------|
| 050       | 31                 | 20    |
| 080       | 16                 | 11    |
| 100       | 8                  | 6     |
| 140       | 4                  | 1     |

**Table E1: Fano Algorithm Coefficients**

Reference Text: Lin and Costello, "Error Control Coding: Fundamentals and Applications," Prentice Hall, 1983.

Reference Text: C. Britton Rorabaugh, "Error Coding Cookbook," McGraw Hill, 1996.



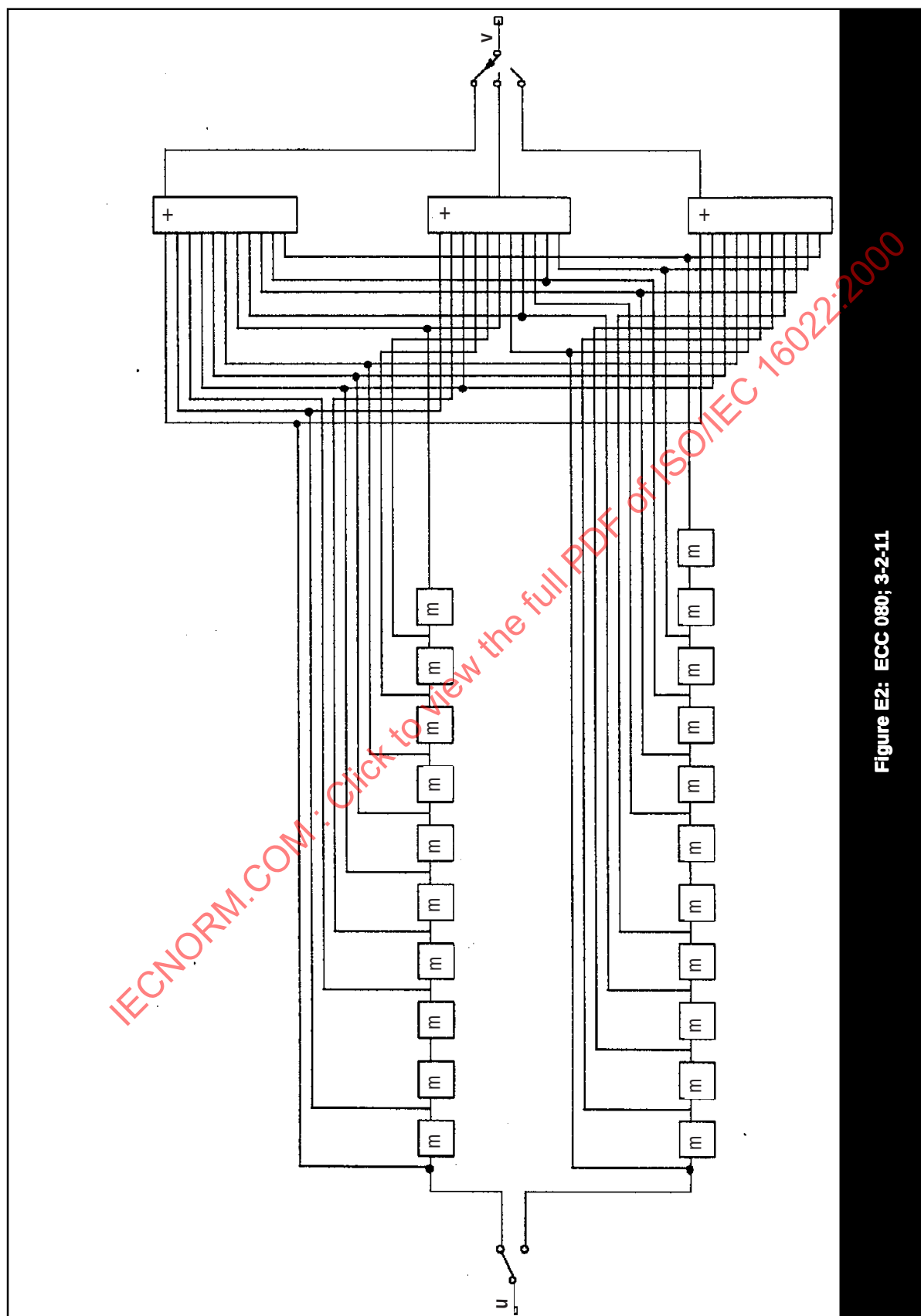
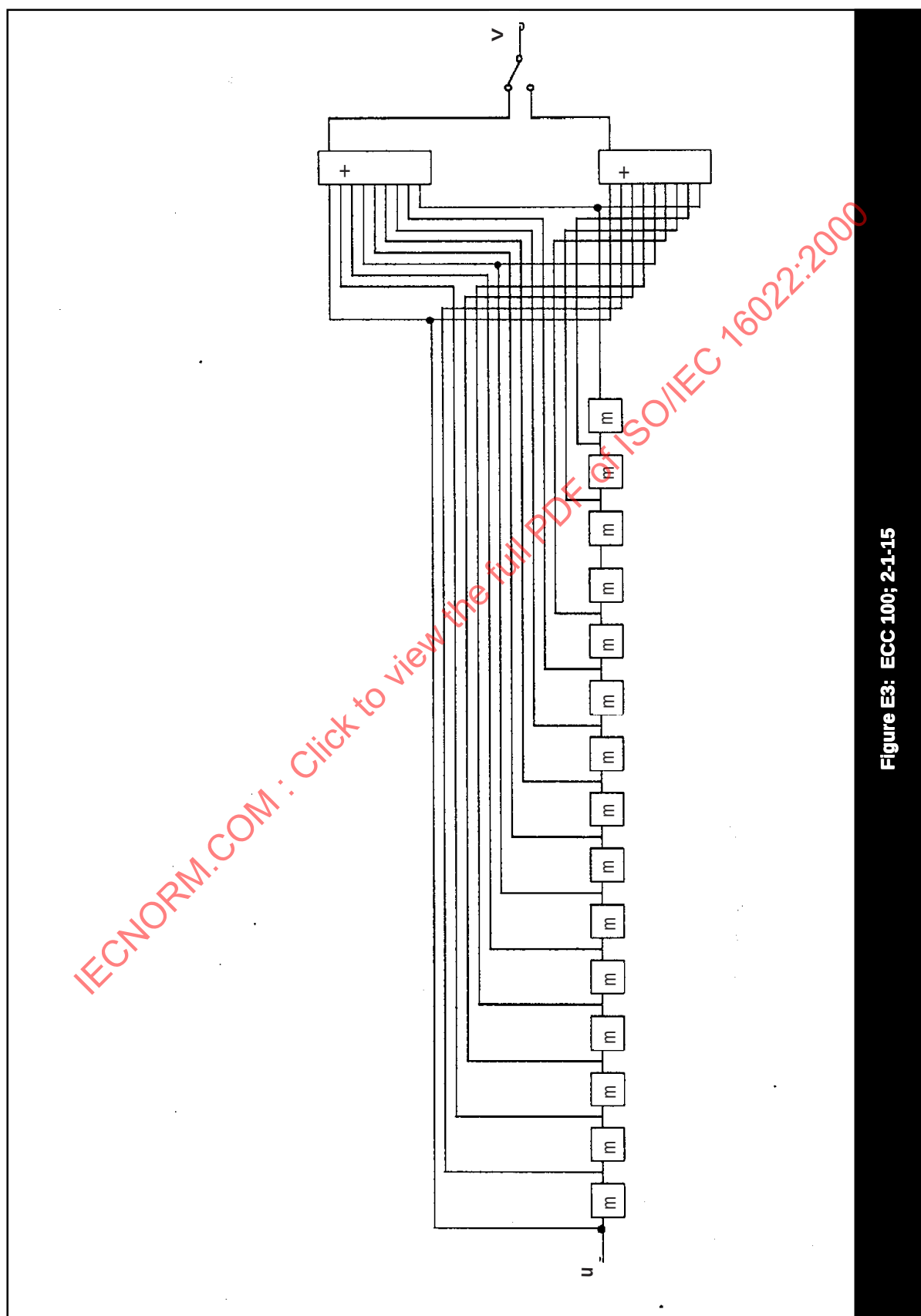


Figure E2: ECC 080; 3-2-11



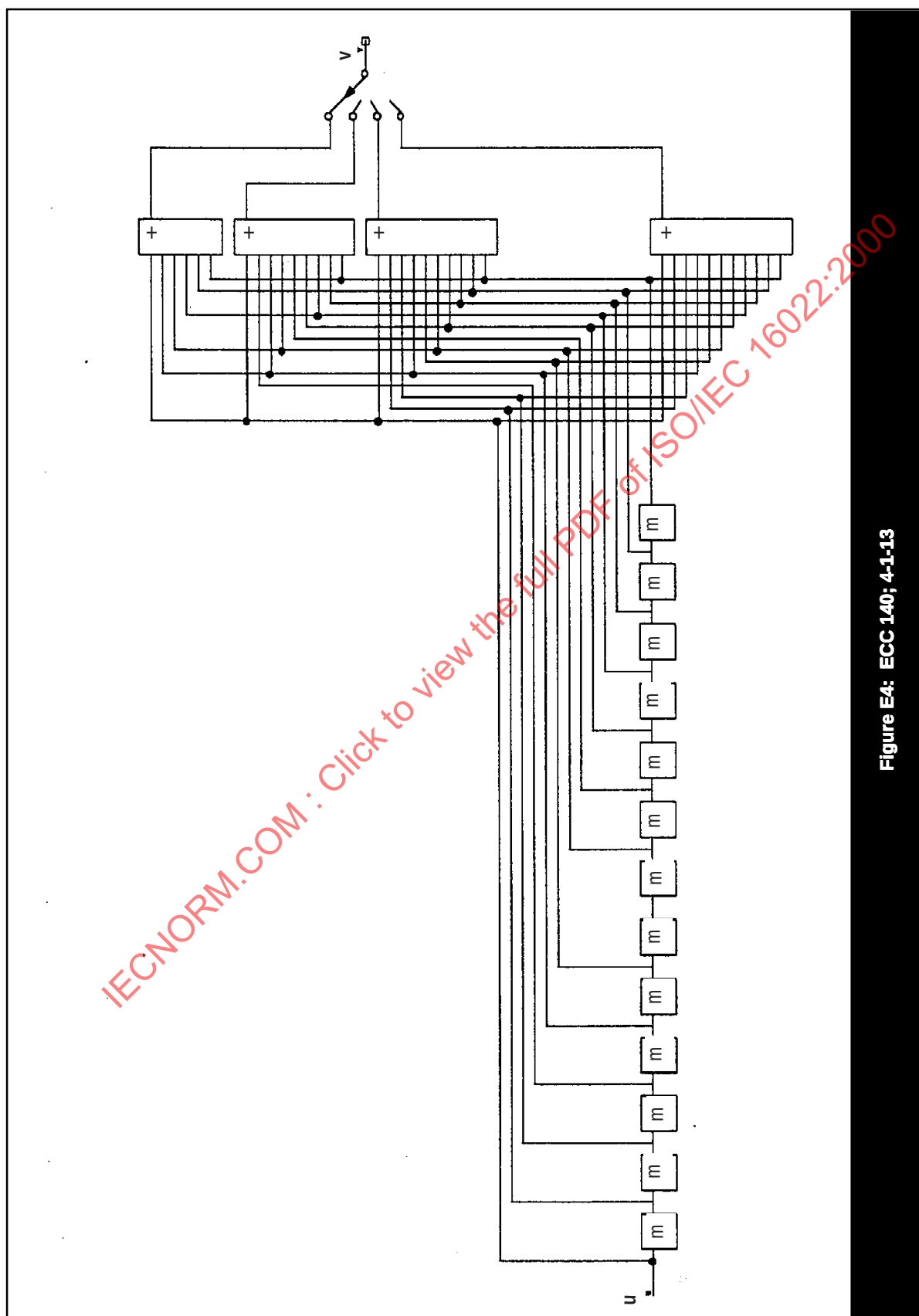


Figure E4: ECC 140; 4-1-13

*Annexe F (Normative)**ECC 000 - 140 Master Random Bit Stream (in hexadecimal)*

(MSB)

|    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |       |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-------|
| 05 | ff | c7 | 31 | 88 | a8 | 83 | 9c | 64 | 87 | 9f | 64 | b3 | e0 | 4d | 9c | 80 | 29 | 3a | 90    |
| b3 | 8b | 9e | 90 | 45 | bf | f5 | 68 | 4b | 08 | cf | 44 | b8 | d4 | 4c | 5b | a0 | ab | 72 | 52    |
| 1c | e4 | d2 | 74 | a4 | da | 8a | 08 | fa | a7 | c7 | dd | 00 | 30 | a9 | e6 | 64 | ab | d5 | 8b    |
| ed | 9c | 79 | f8 | 08 | d1 | 8b | c6 | 22 | 64 | 0b | 33 | 43 | d0 | 80 | d4 | 44 | 95 | 2e | 6f    |
| 5e | 13 | 8d | 47 | 62 | 06 | eb | 80 | 82 | c9 | 41 | d5 | 73 | 8a | 30 | 23 | 24 | e3 | 7f | b2    |
| a8 | 0b | ed | 38 | 42 | 4c | d7 | b0 | ce | 98 | bd | e1 | d5 | e4 | c3 | 1d | 15 | 4a | cf | d1    |
| 1f | 39 | 26 | 18 | 93 | fc | 19 | b2 | 2d | ab | f2 | 6e | a1 | 9f | af | d0 | 8a | 2b | a0 | 56    |
| b0 | 41 | 6d | 43 | a4 | 63 | f3 | aa | 7d | af | 35 | 57 | c2 | 94 | 4a | 65 | 0b | 41 | de | b8    |
| e2 | 30 | 12 | 27 | 9b | 66 | 2b | 34 | 5b | b8 | 99 | e8 | 28 | 71 | d0 | 95 | 6b | 07 | 4d | 3c    |
| 7a | b3 | e5 | 29 | b3 | ba | 8c | cc | 2d | e0 | c9 | c0 | 22 | ec | 4c | de | f8 | 58 | 07 | fc    |
| 19 | f2 | 64 | e2 | c3 | e2 | d8 | b9 | fd | 67 | a0 | bc | f5 | 2e | c9 | 49 | 75 | 62 | 82 | 27    |
| 10 | f4 | 19 | 6f | 49 | f7 | b3 | 84 | 14 | ea | eb | e1 | 2a | 31 | ab | 47 | 7d | 08 | 29 | ac    |
| bb | 72 | fa | fa | 62 | b8 | c8 | d3 | 86 | 89 | 95 | fd | df | cc | 9c | ad | f1 | d4 | 6c | 64    |
| 23 | 24 | 2a | 56 | 1f | 36 | eb | b7 | d6 | ff | da | 57 | f4 | 50 | 79 | 08 | 0  |    |    | (LSB) |

Annexe G (Normative)

ECC 200 Interleaving Process

G.1 Schematic Illustration

Using the example of the 72 x 72 symbol size, four levels of interleaving are required to encode a total of 368 data codewords and 144 error correction codewords. These are divided into four blocks of 92 data codewords and 36 error correction codewords, a total block length of 128 codewords.

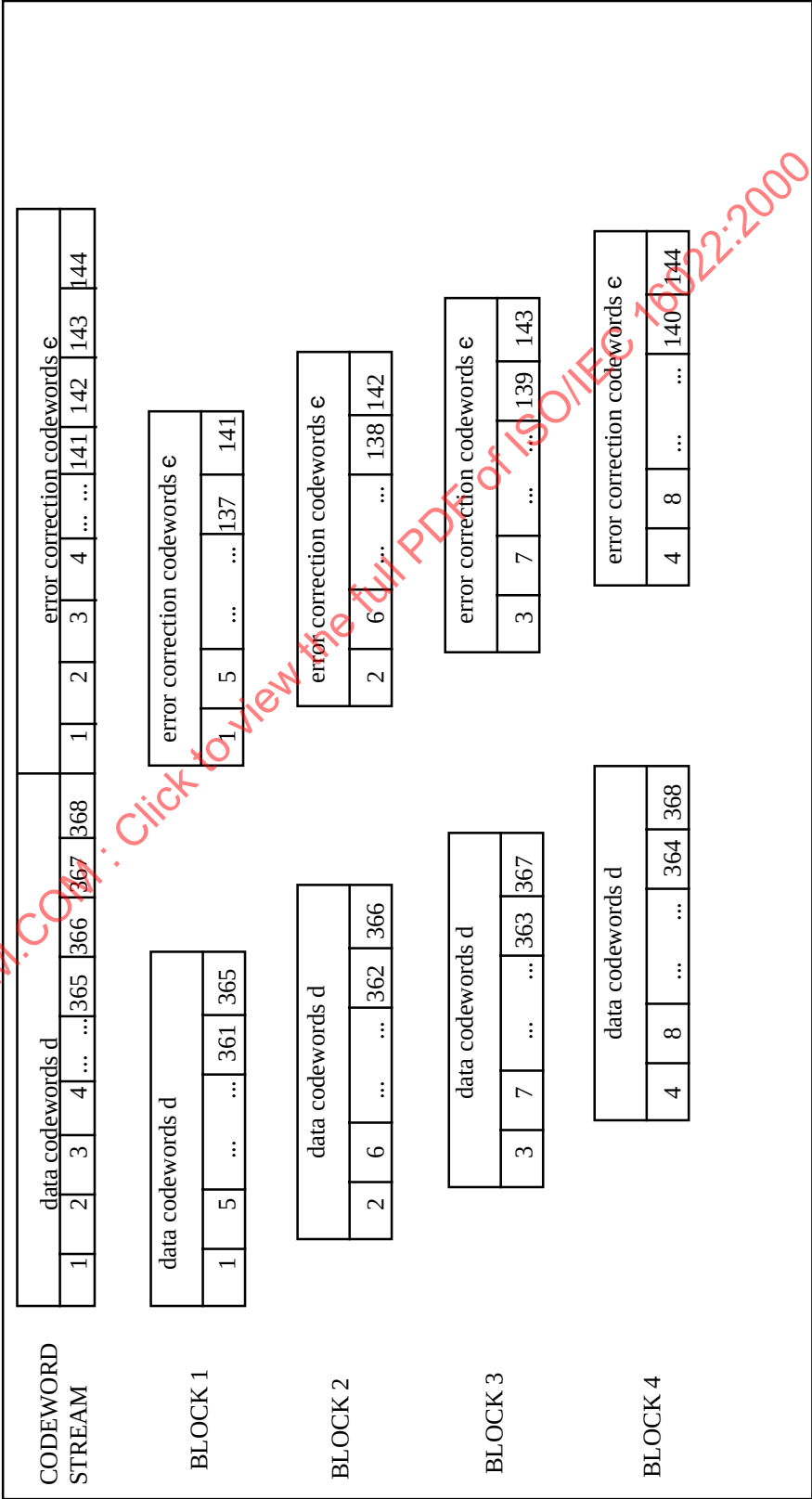


Figure G1: Illustration of Interleaving for 72 x 72 Symbol

### G.2 Starting Sequence for Interleaving in Different Sized Symbols

The sequence of the interleaved data codewords and error correction codewords is given in Table G1.

| Symbol Size | Reed-Solomon Block | Sequence of Data Codewords |     |            | Sequence of Error Correction Codewords |     |          |
|-------------|--------------------|----------------------------|-----|------------|----------------------------------------|-----|----------|
| 52 x 52     | 1                  | 1, 3, 5                    | ... | 201, 203   | 1, 3, 5                                | ... | 81, 83   |
|             | 2                  | 2, 4, 6                    | ... | 202, 204   | 2, 4, 6                                | ... | 82, 84   |
| 64 x 64     | 1                  | 1, 3, 5                    | ... | 277, 279   | 1, 3, 5                                | ... | 109, 111 |
|             | 2                  | 2, 4, 6                    | ... | 278, 280   | 2, 4, 6                                | ... | 110, 112 |
| 72 x 72     | 1                  | 1, 5, 9                    | ... | 361, 365   | 1, 5, 9                                | ... | 137, 141 |
|             | 2                  | 2, 6, 10                   | ... | 362, 366   | 2, 6, 10                               | ... | 138, 142 |
|             | 3                  | 3, 7, 11                   | ... | 363, 367   | 3, 7, 11                               | ... | 139, 143 |
|             | 4                  | 4, 8, 12                   | ... | 364, 368   | 4, 8, 12                               | ... | 140, 144 |
| 80 x 80     | 1                  | 1, 5, 9                    | ... | 449, 453   | 1, 5, 9                                | ... | 185, 189 |
|             | 2                  | 2, 6, 10                   | ... | 450, 454   | 2, 6, 10                               | ... | 186, 190 |
|             | 3                  | 3, 7, 11                   | ... | 451, 455   | 3, 7, 11                               | ... | 187, 191 |
|             | 4                  | 4, 8, 12                   | ... | 452, 456   | 4, 8, 12                               | ... | 188, 192 |
| 88 x 88     | 1                  | 1, 5, 9                    | ... | 569, 573   | 1, 5, 9                                | ... | 217, 221 |
|             | 2                  | 2, 6, 10                   | ... | 570, 574   | 2, 6, 10                               | ... | 218, 222 |
|             | 3                  | 3, 7, 11                   | ... | 571, 575   | 3, 7, 11                               | ... | 219, 223 |
|             | 4                  | 4, 8, 12                   | ... | 572, 576   | 4, 8, 12                               | ... | 220, 224 |
| 96 x 96     | 1                  | 1, 5, 9                    | ... | 689, 693   | 1, 5, 9                                | ... | 265, 269 |
|             | 2                  | 2, 6, 10                   | ... | 690, 694   | 2, 6, 10                               | ... | 266, 270 |
|             | 3                  | 3, 7, 11                   | ... | 691, 695   | 3, 7, 11                               | ... | 267, 271 |
|             | 4                  | 4, 8, 12                   | ... | 692, 696   | 4, 8, 12                               | ... | 268, 272 |
| 104 x 104   | 1                  | 1, 7, 13                   | ... | 805, 811   | 1, 7, 13                               | ... | 325, 331 |
|             | 2                  | 2, 8, 14                   | ... | 806, 812   | 2, 8, 14                               | ... | 326, 332 |
|             | 3                  | 3, 9, 15                   | ... | 807, 813   | 3, 9, 15                               | ... | 327, 333 |
|             | 4                  | 4, 10, 16                  | ... | 808, 814   | 4, 10, 16                              | ... | 328, 334 |
|             | 5                  | 5, 11, 17                  | ... | 809, 815   | 5, 11, 17                              | ... | 329, 335 |
|             | 6                  | 6, 12, 18                  | ... | 810, 816   | 6, 12, 18                              | ... | 330, 336 |
| 120 x 120   | 1                  | 1, 7, 13                   | ... | 1039, 1045 | 1, 7, 13                               | ... | 397, 403 |
|             | 2                  | 2, 8, 14                   | ... | 1040, 1046 | 2, 8, 14                               | ... | 398, 404 |
|             | 3                  | 3, 9, 15                   | ... | 1041, 1047 | 3, 9, 15                               | ... | 399, 405 |
|             | 4                  | 4, 10, 16                  | ... | 1042, 1048 | 4, 10, 16                              | ... | 400, 406 |
|             | 5                  | 5, 11, 17                  | ... | 1043, 1049 | 5, 11, 17                              | ... | 401, 407 |
|             | 6                  | 6, 12, 18                  | ... | 1044, 1050 | 6, 12, 18                              | ... | 402, 408 |

**Table G1: Sequence of Data and Error Correction Codewords for Different Symbol Sizes**

| Symbol Size                                                                                                                                | Reed-Solomon Block | Sequence of Data Codewords |     |            | Sequence of Error Correction Codewords |     |          |
|--------------------------------------------------------------------------------------------------------------------------------------------|--------------------|----------------------------|-----|------------|----------------------------------------|-----|----------|
| 132 x 132                                                                                                                                  | 1                  | 1, 9, 17                   | ... | 1289, 1297 | 1, 9, 17                               | ... | 481, 489 |
|                                                                                                                                            | 2                  | 2, 10, 18                  | ... | 1290, 1298 | 2, 10, 18                              | ... | 482, 490 |
|                                                                                                                                            | 3                  | 3, 11, 19                  | ... | 1291, 1299 | 3, 11, 19                              | ... | 483, 491 |
|                                                                                                                                            | 4                  | 4, 12, 20                  | ... | 1292, 1300 | 4, 12, 20                              | ... | 484, 492 |
|                                                                                                                                            | 5                  | 5, 13, 21                  | ... | 1293, 1301 | 5, 13, 21                              | ... | 485, 493 |
|                                                                                                                                            | 6                  | 6, 14, 22                  | ... | 1294, 1302 | 6, 14, 22                              | ... | 486, 494 |
|                                                                                                                                            | 7                  | 7, 15, 23                  | ... | 1295, 1303 | 7, 15, 23                              | ... | 487, 495 |
|                                                                                                                                            | 8                  | 8, 16, 24                  | ... | 1296, 1304 | 8, 16, 24                              | ... | 488, 496 |
| 144 x 144                                                                                                                                  | 1                  | 1, 11, 21                  | ... | 1541, 1551 | 1, 11, 21                              | ... | 601, 611 |
|                                                                                                                                            | 2                  | 2, 12, 22                  | ... | 1542, 1552 | 2, 12, 22                              | ... | 602, 612 |
|                                                                                                                                            | 3                  | 3, 13, 23                  | ... | 1543, 1553 | 3, 13, 23                              | ... | 603, 613 |
|                                                                                                                                            | 4                  | 4, 14, 24                  | ... | 1544, 1554 | 4, 14, 24                              | ... | 604, 614 |
|                                                                                                                                            | 5                  | 5, 15, 25                  | ... | 1545, 1555 | 5, 15, 25                              | ... | 605, 615 |
|                                                                                                                                            | 6                  | 6, 16, 26                  | ... | 1546, 1556 | 6, 16, 26                              | ... | 606, 616 |
|                                                                                                                                            | 7                  | 7, 17, 27                  | ... | 1547, 1557 | 7, 17, 27                              | ... | 607, 617 |
|                                                                                                                                            | 8                  | 8, 18, 28                  | ... | 1548, 1558 | 8, 18, 28                              | ... | 608, 618 |
|                                                                                                                                            | 9                  | 9, 19, 29                  | ... | 1549       | 9, 19, 29                              | ... | 609, 619 |
|                                                                                                                                            | 10                 | 10, 20, 30                 | ... | 1550       | 10, 20, 30                             | ... | 610, 620 |
| Note: The 9th and 10th blocks of the 144 x 144 symbol have only 155 data codewords, whereas the other eight blocks have 156 data codewords |                    |                            |     |            |                                        |     |          |
| <b>Table G1: Sequence of Data and Error Correction Codewords for Different Symbol Sizes (concluded)</b>                                    |                    |                            |     |            |                                        |     |          |

## Annexe H (Normative)

### ECC 200 Pattern Randomizing

The pattern randomizing algorithms convert an input codeword at a given position to new randomized output codeword.

#### H.1 253-State Algorithm

This algorithm adds a pseudo-random number to the Pad codeword value. The pseudo-random number will always be in the range 1 to 253 and the randomized Pad codeword value be in the range 1 to 254.

The variable Pad\_codeword\_position is the number of data codewords from the beginning of encoded data.

##### H.1.1 253-State Randomizing Algorithm

```

INPUT ( Pad_codeword_value,
Pad_codeword_position )
pseudo_random_number = ( ( 149 *
    Pad_codeword_position ) mod 253 ) + 1
temp_variable = Pad_codeword_value +
    pseudo_random_number
IF ( temp_variable <= 254 )
    OUTPUT ( randomized_Pad_codeword_value =
        temp_variable )
ELSE
    OUTPUT ( randomized_Pad_codeword_value =
        temp_variable - 254 )

```

##### H.1.2 253-State Un-Randomizing Algorithm

```

INPUT ( randomized_Pad_codeword_value,
Pad_codeword_position )
pseudo_random_number = ( ( 149 *
    Pad_codeword_position ) mod 253 ) + 1
temp_variable = randomized_Pad_codeword_value -
    pseudo_random_number
IF ( temp_variable >= 1 )
    OUTPUT ( Pad_codeword_value =
        temp_variable )
ELSE
    OUTPUT ( Pad_codeword_value =
        temp_variable + 254 )

```

#### H.2 255-State Algorithm

This algorithm adds a pseudo-random number to the Base 256 Encodation codeword value. The pseudo-random number will always be in the range 1 to 255 and the randomized Base 256 codeword value be in the range 0 to 255.

The variable Base256\_codeword\_position is the number of data codewords from the beginning of encoded data.

##### H.2.1 255-State Randomizing Algorithm

```

INPUT ( Base256_codeword_value,
Base256_codeword_position )
pseudo_random_number = ( ( 149 *
    Base256_codeword_position ) mod 255 ) + 1
temp_variable = Base256_codeword_value +
    pseudo_random_number
IF ( temp_variable <= 255 )
    OUTPUT
        (randomized_Base256_codeword_value
        = temp_variable )
ELSE
    OUTPUT
        (randomized_Base256_codeword_value
        = temp_variable - 256 )

```

##### H.2.2 255-State Un-Randomizing Algorithm

```

INPUT ( randomized_Base256_codeword_value,
Base256_codeword_position )
pseudo_random_number = ( ( 149 *
    Base256_codeword_position ) mod 255 ) + 1
temp_variable = randomized_Base256_codeword_value -
    pseudo_random_number
IF ( temp_variable >= 0 )
    OUTPUT ( Base256_codeword_value =
        temp_variable )
ELSE
    OUTPUT ( Base256_codeword_value =
        temp_variable + 256 )

```

*Annexe J (Normative)**ECC 200 Encodation Character Sets**J.1 C40 Encodation Character Set*

| C40 Value | Basic Set<br>Char    Decimal | Shift 1 Set<br>Char    Decimal | Shift 2 Set<br>Char    Decimal | Shift 3 Set<br>Char    Decimal |
|-----------|------------------------------|--------------------------------|--------------------------------|--------------------------------|
| 0         | Shift 1                      | NUL    0                       | !        33                    | ‘        96                    |
| 1         | Shift 2                      | SOH    1                       | “        34                    | a        97                    |
| 2         | Shift 3                      | STX    2                       | #        35                    | b        98                    |
| 3         | space    32                  | ETX    3                       | \$        36                   | c        99                    |
| 4         | 0        48                  | EOT    4                       | %        37                    | d        100                   |
| 5         | 1        49                  | ENQ    5                       | &        38                    | e        101                   |
| 6         | 2        50                  | ACK    6                       | ‘        39                    | f        102                   |
| 7         | 3        51                  | BEL    7                       | (        40                    | g        103                   |
| 8         | 4        52                  | BS      8                      | )        41                    | h        104                   |
| 9         | 5        53                  | HT      9                      | *        42                    | i        105                   |
| 10        | 6        54                  | LF      10                     | +        43                    | j        106                   |
| 11        | 7        55                  | VT      11                     | ,        44                    | k        107                   |
| 12        | 8        56                  | FF      12                     | -        45                    | l        108                   |
| 13        | 9        57                  | CR      13                     | .        46                    | m        109                   |
| 14        | A        65                  | SO      14                     | /        47                    | n        110                   |
| 15        | B        66                  | SI      15                     | :        58                    | o        111                   |
| 16        | C        67                  | DLE    16                      | ;        59                    | p        112                   |
| 17        | D        68                  | DC1    17                      | <        60                    | q        113                   |
| 18        | E        69                  | DC2    18                      | =        61                    | r        114                   |
| 19        | F        70                  | DC3    19                      | >        62                    | s        115                   |
| 20        | G        71                  | DC4    20                      | ?        63                    | t        116                   |
| 21        | H        72                  | NAK    21                      | @        64                    | u        117                   |
| 22        | I        73                  | SYN    22                      | [        91                    | v        118                   |
| 23        | J        74                  | ETB    23                      | \        92                    | w        119                   |
| 24        | K        75                  | CAN    24                      | ]        93                    | x        120                   |
| 25        | L        76                  | EM      25                     | ^        94                    | y        121                   |
| 26        | M        77                  | SUB    26                      | _        95                    | z        122                   |
| 27        | N        78                  | ESC    27                      | FNC1                           | {        123                   |
| 28        | O        79                  | FS      28                     |                                | 124                            |
| 29        | P        80                  | GS      29                     |                                | }        125                   |
| 30        | Q        81                  | RS      30                     | Upper Shift                    | ~        126                   |
| 31        | R        82                  | US      31                     |                                | DEL    127                     |
| 32        | S        83                  |                                |                                |                                |
| 33        | T        84                  |                                |                                |                                |
| 34        | U        85                  |                                |                                |                                |
| 35        | V        86                  |                                |                                |                                |
| 36        | W        87                  |                                |                                |                                |
| 37        | X        88                  |                                |                                |                                |
| 38        | Y        89                  |                                |                                |                                |
| 39        | Z        90                  |                                |                                |                                |

Note: The relationship between the ASCII decimal value and the C40 value remain constant regardless of which ECI is in effect.

## J.2 Text Encodation Character Set

| Text Value | Basic Set Char | Decimal | Shift 1 Set Char | Decimal | Shift 2 Set Char | Decimal | Shift 3 Set Char | Decimal |
|------------|----------------|---------|------------------|---------|------------------|---------|------------------|---------|
| 0          | Shift 1        |         | NUL              | 0       | !                | 33      | '                | 96      |
| 1          | Shift 2        |         | SOH              | 1       | "                | 34      | A                | 65      |
| 2          | Shift 3        |         | STX              | 2       | #                | 35      | B                | 66      |
| 3          | space          | 32      | ETX              | 3       | \$               | 36      | C                | 67      |
| 4          | 0              | 48      | EOT              | 4       | %                | 37      | D                | 68      |
| 5          | 1              | 49      | ENQ              | 5       | &                | 38      | E                | 69      |
| 6          | 2              | 50      | ACK              | 6       | '                | 39      | F                | 70      |
| 7          | 3              | 51      | BEL              | 7       | (                | 40      | G                | 71      |
| 8          | 4              | 52      | BS               | 8       | )                | 41      | H                | 72      |
| 9          | 5              | 53      | HT               | 9       | *                | 42      | I                | 73      |
| 10         | 6              | 54      | LF               | 10      | +                | 43      | J                | 74      |
| 11         | 7              | 55      | VT               | 11      | ,                | 44      | K                | 75      |
| 12         | 8              | 56      | FF               | 12      | -                | 45      | L                | 76      |
| 13         | 9              | 57      | CR               | 13      | .                | 46      | M                | 77      |
| 14         | a              | 97      | SO               | 14      | /                | 47      | N                | 78      |
| 15         | b              | 98      | SI               | 15      | :                | 58      | O                | 79      |
| 16         | c              | 99      | DLE              | 16      | ;                | 59      | P                | 80      |
| 17         | d              | 100     | DC1              | 17      | <                | 60      | Q                | 81      |
| 18         | e              | 101     | DC2              | 18      | =                | 61      | R                | 82      |
| 19         | f              | 102     | DC3              | 19      | >                | 62      | S                | 83      |
| 20         | g              | 103     | DC4              | 20      | ?                | 63      | T                | 84      |
| 21         | h              | 104     | NAK              | 21      | @                | 64      | U                | 85      |
| 22         | i              | 105     | SYN              | 22      | [                | 91      | V                | 86      |
| 23         | j              | 106     | ETB              | 23      | \                | 92      | W                | 87      |
| 24         | k              | 107     | CAN              | 24      | ]                | 93      | X                | 88      |
| 25         | l              | 108     | EM               | 25      | ^                | 94      | Y                | 89      |
| 26         | m              | 109     | SUB              | 26      | _                | 95      | Z                | 90      |
| 27         | n              | 110     | ESC              | 27      | FNC1             |         | {                | 123     |
| 28         | o              | 111     | FS               | 28      |                  |         |                  | 124     |
| 29         | p              | 112     | GS               | 29      |                  |         | }                | 125     |
| 30         | q              | 113     | RS               | 30      | Upper Shift      |         | ~                | 126     |
| 31         | r              | 114     | US               | 31      |                  |         | DEL              | 127     |
| 32         | s              | 115     |                  |         |                  |         |                  |         |
| 33         | t              | 116     |                  |         |                  |         |                  |         |
| 34         | u              | 117     |                  |         |                  |         |                  |         |
| 35         | v              | 118     |                  |         |                  |         |                  |         |
| 36         | w              | 119     |                  |         |                  |         |                  |         |
| 37         | x              | 120     |                  |         |                  |         |                  |         |
| 38         | y              | 121     |                  |         |                  |         |                  |         |
| 39         | z              | 122     |                  |         |                  |         |                  |         |

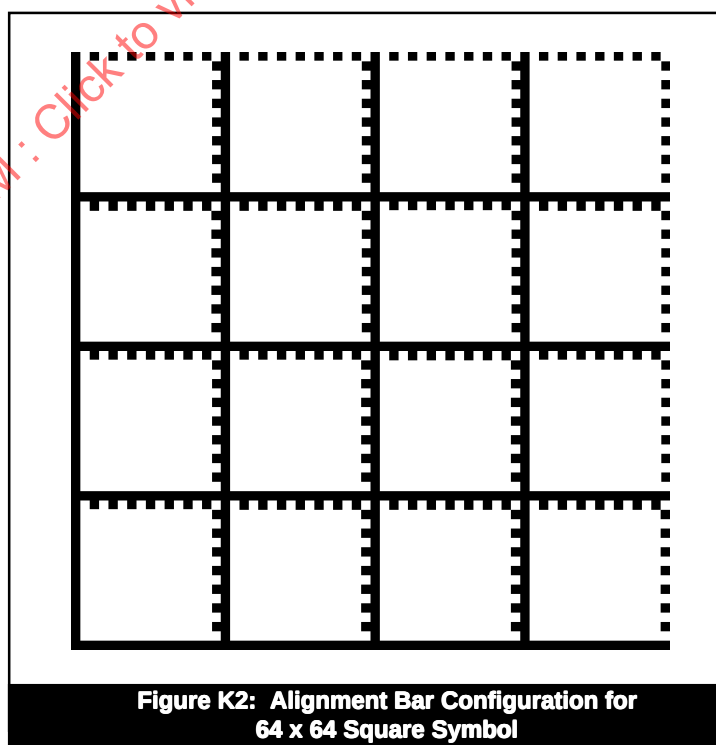
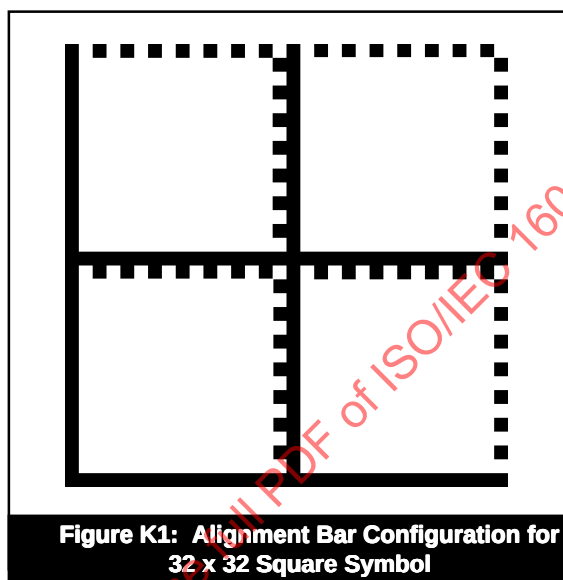
Note: The relationship between the ASCII decimal value and the Text value remain constant regardless of which ECI is in effect.

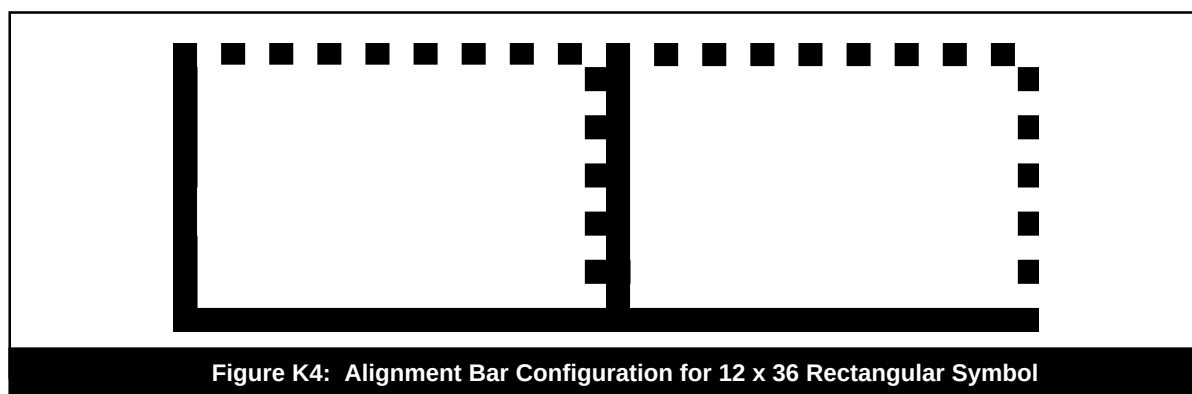
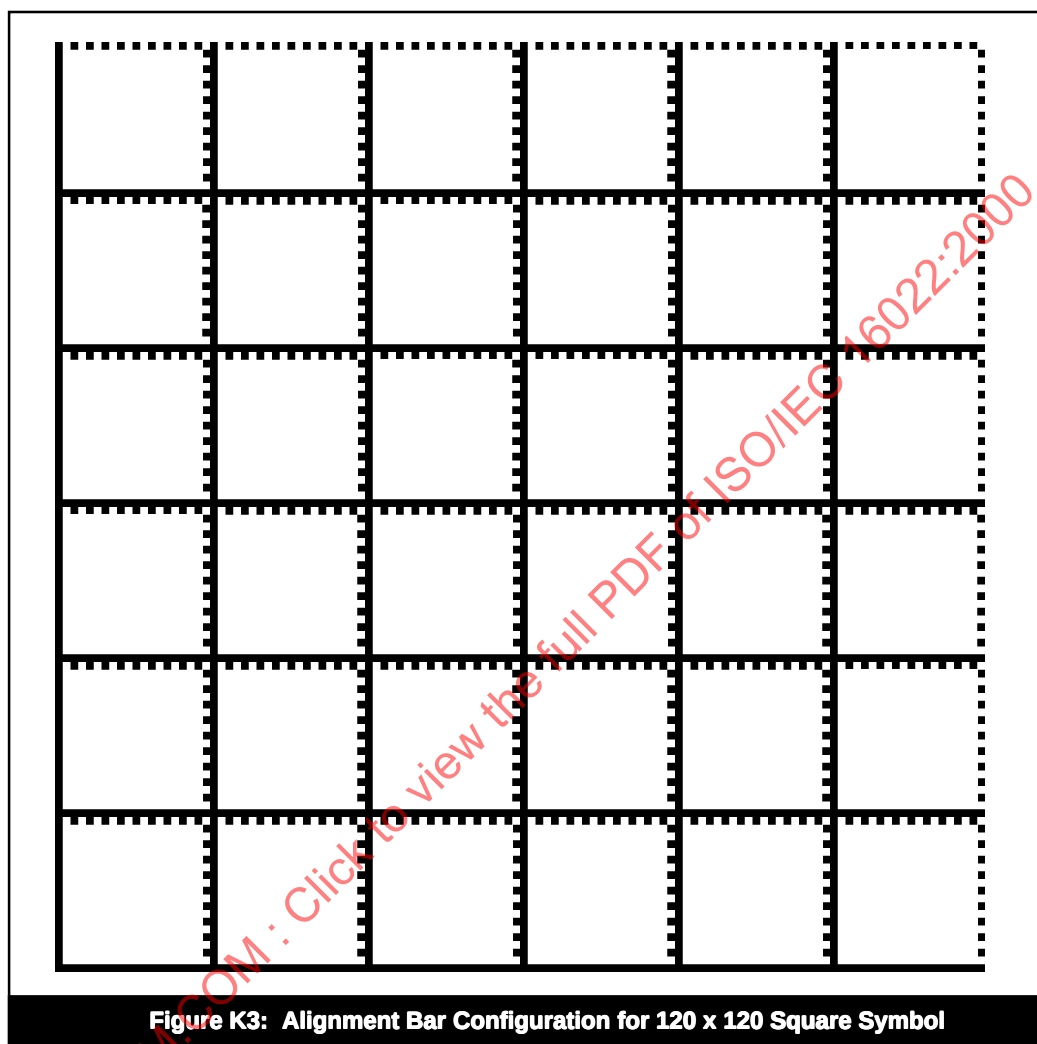
## J.3 EDIFACT Encodation Character Set

| Data Character |               |              |                      | Data Character |               |              |                      |
|----------------|---------------|--------------|----------------------|----------------|---------------|--------------|----------------------|
| Char           | Decimal Value | Binary Value | EDIFACT Binary Value | Char           | Decimal Value | Binary Value | EDIFACT Binary Value |
| @              | 64            | 01000000     | 000000               | space          | 32            | 00100000     | 100000               |
| A              | 65            | 01000001     | 000001               | !              | 33            | 00100001     | 100001               |
| B              | 66            | 01000010     | 000010               | "              | 34            | 00100010     | 100010               |
| C              | 67            | 01000011     | 000011               | #              | 35            | 00100011     | 100011               |
| D              | 68            | 01000100     | 000100               | \$             | 36            | 00100100     | 100100               |
| E              | 69            | 01000101     | 000101               | %              | 37            | 00100101     | 100101               |
| F              | 70            | 01000110     | 000110               | &              | 38            | 00100110     | 100110               |
| G              | 71            | 01000111     | 000111               | '              | 39            | 00100111     | 100111               |
| H              | 72            | 01001000     | 001000               | (              | 40            | 00101000     | 101000               |
| I              | 73            | 01001001     | 001001               | )              | 41            | 00101001     | 101001               |
| J              | 74            | 01001010     | 001010               | *              | 42            | 00101010     | 101010               |
| K              | 75            | 01001011     | 001011               | +              | 43            | 00101011     | 101011               |
| L              | 76            | 01001100     | 001100               | ,              | 44            | 00101100     | 101100               |
| M              | 77            | 01001101     | 001101               | -              | 45            | 00101101     | 101101               |
| N              | 78            | 01001110     | 001110               | .              | 46            | 00101110     | 101110               |
| O              | 79            | 01001111     | 001111               | /              | 47            | 00101111     | 101111               |
| P              | 80            | 01010000     | 010000               | 0              | 48            | 00110000     | 110000               |
| Q              | 81            | 01010001     | 010001               | 1              | 49            | 00110001     | 110001               |
| R              | 82            | 01010010     | 010010               | 2              | 50            | 00110010     | 110010               |
| S              | 83            | 01010011     | 010011               | 3              | 51            | 00110011     | 110011               |
| T              | 84            | 01010100     | 010100               | 4              | 52            | 00110100     | 110100               |
| U              | 85            | 01010101     | 010101               | 5              | 53            | 00110101     | 110101               |
| V              | 86            | 01010110     | 010110               | 6              | 54            | 00110110     | 110110               |
| W              | 87            | 01010111     | 010111               | 7              | 55            | 00110111     | 110111               |
| X              | 88            | 01011000     | 011000               | 8              | 56            | 00111000     | 111000               |
| Y              | 89            | 01011001     | 011001               | 9              | 57            | 00111001     | 111001               |
| Z              | 90            | 01011010     | 011010               | :              | 58            | 00111010     | 111010               |
| [              | 91            | 01011011     | 011011               | ;              | 59            | 00111011     | 111011               |
| \              | 92            | 01011100     | 011100               | <              | 60            | 00111100     | 111100               |
| ]              | 93            | 01011101     | 011101               | =              | 61            | 00111101     | 111101               |
| ^              | 94            | 01011110     | 011110               | >              | 62            | 00111110     | 111110               |
| Unlatch        |               | 01011111     | 011111               | ?              | 63            | 00111111     | 111111               |

Note: The relationship between the ASCII decimal value and the EDIFACT value remain constant regardless of which ECI is in effect.

*Annexe K (Normative)*  
*ECC 200 Alignment Patterns*





## Annexe L (Normative)

### ECC 200 Reed-Solomon Error Detection and Correction

#### L.1 Error Correction Codeword Generator Polynomials

The check character generation polynomial is used to divide the data symbol character polynomial where each symbol character is the coefficient of the dividend polynomial in descending power. The coefficients of the remainder of this division are the error correction symbol character values.

Each generator polynomial is the product of the first degree polynomials:  $x - 2^1, x - 2^2, \dots, x - 2^n$ ; where  $n$  is the degree of the generator polynomial. For example the fifth degree generator polynomial is:

$$\begin{aligned} & (x + 2)(x + 4)(x + 8)(x + 16)(x + 32) \\ &= x^5 + (2 + 4 + 8 + 16 + 32)x^4 + ((2*4) + (2*8) + (2*16) + (2*32) + (4*8) + (4*16) + (4*32) + (8*16) + (8*32) + (16*32))x^3 + \\ & \quad ((2*4*8) + (2*4*16) + (2*4*32) + (2*8*16) + (2*8*32) + (2*16*32) + (4*8*16) + (4*8*32) + (4*16*32) + (8*16*32))x^2 + ((2*4*8*16) + (2*4*8*32) + (2*4*16*32) + (2*8*16*32) + (4*8*16*32))x + (2*4*8*16*32) \\ &= x^5 + 62x^4 + 111x^3 + 15x^2 + 48x + 228. \end{aligned}$$

Note that this Galois Field arithmetic is not normal integer arithmetic:  $-$  is equivalent to  $+$  which is an “exclusive-or” operation in this Field, and multiplication is bitwise modulo 100101101 for each binary polynomial term generated by bit-by-bit multiplication.

The polynomial divisor for generating 5 check characters is:

$$g(x) = x^5 + 62x^4 + 111x^3 + 15x^2 + 48x + 228.$$

The polynomial divisor for generating 7 check characters is:

$$g(x) = x^7 + 254x^6 + 92x^5 + 240x^4 + 134x^3 + 144x^2 + 68x + 23.$$

The polynomial divisor for generating 10 check characters is:

$$g(x) = x^{10} + 61x^9 + 110x^8 + 255x^7 + 116x^6 + 248x^5 + 223x^4 + 166x^3 + 185x^2 + 24x + 28.$$

The polynomial divisor for generating 11 check characters is:

$$g(x) = x^{11} + 120x^{10} + 97x^9 + 60x^8 + 245x^7 + 39x^6 + 168x^5 + 194x^4 + 12x^3 + 205x^2 + 138x + 175.$$

The polynomial divisor for generating 12 check characters is:

$$g(x) = x^{12} + 242x^{11} + 100x^{10} + 178x^9 + 97x^8 + 213x^7 + 142x^6 + 42x^5 + 61x^4 + 91x^3 + 158x^2 + 153x + 41.$$

The polynomial divisor for generating 14 check characters is:

$$g(x) = x^{14} + 185x^{13} + 83x^{12} + 186x^{11} + 18x^{10} + 45x^9 + 138x^8 + 119x^7 + 157x^6 + 9x^5 + 95x^4 + 252x^3 + 192x^2 + 97x + 156.$$

The polynomial divisor for generating 18 check characters is:

$$g(x) = x^{18} + 188x^{17} + 90x^{16} + 48x^{15} + 225x^{14} + 254x^{13} + 94x^{12} + 129x^{11} + 109x^{10} + 213x^9 + 241x^8 + 61x^7 + 66x^6 + 75x^5 + 188x^4 + 39x^3 + 100x^2 + 195x + 83.$$

The polynomial divisor for generating 20 check characters is:

$$g(x) = x^{20} + 172x^{19} + 186x^{18} + 174x^{17} + 27x^{16} + 82x^{15} + 108x^{14} + 79x^{13} + 253x^{12} + 145x^{11} + 153x^{10} + 160x^9 + 188x^8 + 2x^7 + 168x^6 + 71x^5 + 233x^4 + 9x^3 + 244x^2 + 195x + 15.$$

The polynomial divisor for generating 24 check characters is:

$$g(x) = x^{24} + 193x^{23} + 50x^{22} + 96x^{21} + 184x^{20} + 181x^{19} + 12x^{18} + 124x^{17} + 254x^{16} + 172x^{15} + 5x^{14} + 21x^{13} + 155x^{12} + 223x^{11} + 251x^{10} + 197x^9 + 155x^8 + 21x^7 + 176x^6 + 39x^5 + 109x^4 + 205x^3 + 88x^2 + 190x + 52.$$

The polynomial divisor for generating 28 check characters is:

$$g(x) = x^{28} + 255x^{27} + 93x^{26} + 168x^{25} + 233x^{24} + 151x^{23} + 120x^{22} + 136x^{21} + 141x^{20} + 213x^{19} + 110x^{18} + 138x^{17} + 17x^{16} + 121x^{15} + 249x^{14} + 34x^{13} + 75x^{12} + 53x^{11} + 170x^{10} + 151x^9 + 37x^8 + 174x^7 + 103x^6 + 96x^5 + 71x^4 + 97x^3 + 43x^2 + 231x + 211.$$

The polynomial divisor for generating 36 check characters is:

$$g(x) = x^{36} + 112x^{35} + 81x^{34} + 98x^{33} + 225x^{32} + 25x^{31} + 59x^{30} + 184x^{29} + 175x^{28} + 44x^{27} + 115x^{26} + 119x^{25} + 95x^{24} + 137x^{23} + 101x^{22} + 33x^{21} + 68x^{20} + 4x^{19} + 2x^{18} + 18x^{17} + 229x^{16} + 182x^{15} + 80x^{14} + 251x^{13} + 220x^{12} + 179x^{11} + 84x^{10} + 120x^9 + 102x^8 + 181x^7 + 162x^6 + 250x^5 + 130x^4 + 218x^3 + 242x^2 + 127x + 245.$$

The polynomial divisor for generating 42 check characters is:

$$g(x) = x^{42} + 5x^{41} + 9x^{40} + 5x^{39} + 226x^{38} + 177x^{37} + 150x^{36} + 50x^{35} + 69x^{34} + 202x^{33} + 248x^{32} + 101x^{31} + 54x^{30} + 57x^{29} + 253x^{28} + x^{27} + 21x^{26} + 121x^{25} + 57x^{24} + 111x^{23} + 214x^{22} + 105x^{21} + 167x^{20} + 9x^{19} + 100x^{18} + 95x^{17} + 175x^{16} + 8x^{15} + 242x^{14} + 133x^{13} + 245x^{12} + 2x^{11} + 122x^{10} + 105x^9 + 247x^8 + 153x^7 + 22x^6 + 38x^5 + 19x^4 + 31x^3 + 137x^2 + 193x + 77.$$

The polynomial divisor for generating 48 check characters is:

$$g(x) = x^{48} + 19x^{47} + 225x^{46} + 253x^{45} + 92x^{44} + 213x^{43} + 69x^{42} + 175x^{41} + 160x^{40} + 147x^{39} + 187x^{38} + 87x^{37} + 176x^{36} + 44x^{35} + 82x^{34} + 240x^{33} + 186x^{32} + 138x^{31} + 66x^{30} + 100x^{29} + 120x^{28} + 88x^{27} + 131x^{26} + 205x^{25} + 170x^{24} + 90x^{23} + 37x^{22} + 23x^{21} + 118x^{20} + 147x^{19} + 16x^{18} + 106x^{17} + 191x^{16} + 87x^{15} + 237x^{14} + 188x^{13} + 205x^{12} + 231x^{11} + 238x^{10} + 133x^9 + 238x^8 + 22x^7 + 117x^6 + 32x^5 + 96x^4 + 223x^3 + 172x^2 + 132x + 245.$$

The polynomial divisor for generating 56 check characters is:

$$g(x) = x^{56} + 46x^{55} + 143x^{54} + 53x^{53} + 233x^{52} + 107x^{51} + 203x^{50} + 43x^{49} + 155x^{48} + 28x^{47} + 247x^{46} + 67x^{45} + 127x^{44} + 245x^{43} + 137x^{42} + 13x^{41} + 164x^{40} + 207x^{39} + 62x^{38} + 117x^{37} + 201x^{36} + 150x^{35} + 22x^{34} + 238x^{33} + 144x^{32} + 232x^{31} + 29x^{30} + 203x^{29} + 117x^{28} + 234x^{27} + 218x^{26} + 146x^{25} + 228x^{24} + 54x^{23} + 132x^{22} + 200x^{21} + 38x^{20} + 223x^{19} + 36x^{18} + 159x^{17} + 150x^{16} + 235x^{15} + 215x^{14} + 192x^{13} + 230x^{12} + 170x^{11} + 175x^{10} + 29x^9 + 100x^8 + 208x^7 + 220x^6 + 17x^5 + 12x^4 + 238x^3 + 223x^2 + 9x + 175.$$

The polynomial divisor for generating 62 check

characters is:

$$g(x) = x^{62} + 204x^{61} + 11x^{60} + 47x^{59} + 86x^{58} + 124x^{57} + 224x^{56} + 166x^{55} + 94x^{54} + 7x^{53} + 232x^{52} + 107x^{51} + 4x^{50} + 170x^{49} + 176x^{48} + 31x^{47} + 163x^{46} + 17x^{45} + 188x^{44} + 130x^{43} + 40x^{42} + 10x^{41} + 87x^{40} + 63x^{39} + 51x^{38} + 218x^{37} + 27x^{36} + 6x^{35} + 147x^{34} + 44x^{33} + 161x^{32} + 71x^{31} + 114x^{30} + 64x^{29} + 175x^{28} + 221x^{27} + 185x^{26} + 106x^{25} + 250x^{24} + 190x^{23} + 197x^{22} + 63x^{21} + 245x^{20} + 230x^{19} + 134x^{18} + 112x^{17} + 185x^{16} + 37x^{15} + 196x^{14} + 108x^{13} + 143x^{12} + 189x^{11} + 201x^{10} + 188x^9 + 202x^8 + 118x^7 + 39x^6 + 210x^5 + 144x^4 + 50x^3 + 169x^2 + 93x + 242.$$

The polynomial divisor for generating 68 check characters is:

$$g(x) = x^{68} + 186x^{67} + 82x^{66} + 103x^{65} + 96x^{64} + 63x^{63} + 132x^{62} + 153x^{61} + 108x^{60} + 54x^{59} + 64x^{58} + 189x^{57} + 211x^{56} + 232x^{55} + 49x^{54} + 25x^{53} + 172x^{52} + 52x^{51} + 59x^{50} + 241x^{49} + 181x^{48} + 239x^{47} + 223x^{46} + 136x^{45} + 231x^{44} + 210x^{43} + 96x^{42} + 232x^{41} + 220x^{40} + 25x^{39} + 179x^{38} + 167x^{37} + 202x^{36} + 185x^{35} + 153x^{34} + 139x^{33} + 66x^{32} + 236x^{31} + 227x^{30} + 160x^{29} + 15x^{28} + 213x^{27} + 93x^{26} + 122x^{25} + 68x^{24} + 177x^{23} + 158x^{22} + 197x^{21} + 234x^{20} + 180x^{19} + 248x^{18} + 136x^{17} + 213x^{16} + 127x^{15} + 73x^{14} + 36x^{13} + 154x^{12} + 244x^{11} + 147x^{10} + 33x^9 + 89x^8 + 56x^7 + 159x^6 + 149x^5 + 251x^4 + 89x^3 + 173x^2 + 228x + 220.$$

## L.2 Error Correction Calculation

The Peterson-Gorenstein-Zierler algorithm may be used to correct errors in decoded ECC 200 symbols. The calculation described below follows this error correcting algorithm, using the Reed-Solomon error correction codewords.

Erasures shall be corrected as errors by initially filling any erasure codeword positions with dummy values.

All calculations shall be done using GF(2<sup>8</sup>) arithmetic operations. Addition and subtraction are equivalent to the binary XOR operation. Multiplication and division can be performed using log and antilog tables.

Construct the symbol character polynomial C(x) = C<sub>n-1</sub>x<sup>n-1</sup> + C<sub>n-2</sub>x<sup>n-2</sup> + ... + C<sub>1</sub>x<sup>1</sup> + C<sub>0</sub> where the n coefficients are the codewords read with C<sub>n-1</sub> being the first symbol character and where n is the total number of symbol characters.

Calculate i syndrome values S<sub>0</sub> through S<sub>i-1</sub> by

evaluating  $C(x)$  at  $x = 2^k$  for  $k = 1$  through  $i$  and where  $i$  is the number of error correction codewords in the symbol.

Form and solve  $j$  simultaneous equations with  $j$  unknowns  $L_0$  through  $L_{j-1}$  using the  $i$  syndromes:

$$\begin{aligned} S_0 L_0 + S_1 L_1 + \dots + S_{j-1} L_{j-1} &= S_j \\ S_1 L_0 + S_2 L_1 + \dots + S_j L_{j-1} &= S_{j+1} \\ &\vdots \\ S_{j-1} L_0 + S_j L_1 + \dots + S_{2j-2} L_{j-1} &= S_{2j-1} \end{aligned}$$

where  $j$  is  $i/2$ .

Construct the error locator polynomial:

$$L(x) = L_{j-1} x^j + L_{j-2} x^{j-1} + \dots + L_0 x + 1$$

from the  $j$  values of  $L$  obtained above. Evaluate  $L(x)$  at  $x = 2^k$  for  $k = 0$  through  $n-1$  where  $n$  is the total number of symbol characters in the symbol.

Whenever  $L(2^k) = 0$ , an error location is given by  $n-1-k$ . If more than  $j$  error locations are found, the symbol is not correctable.

Save the error locations in  $m$  error location variables  $E_0$  through  $E_{m-1}$  where  $m$  is the number of error locations found. Form and solve  $m$  simultaneous equations with  $m$  unknowns  $X_0$  through  $X_{m-1}$  (the error magnitudes) using the error location variables  $E$  and the first  $m$  syndromes  $S$ :

$$\begin{aligned} E_0 X_0 + E_1 X_1 + \dots + E_{m-1} X_{m-1} &= S_0 \\ E_0^2 X_0 + E_1^2 X_1 + \dots + E_{m-1}^2 X_{m-1} &= S_1 \\ E_0^3 X_0 + E_1^3 X_1 + \dots + E_{m-1}^3 X_{m-1} &= S_2 \\ &\vdots \\ E_0^m X_0 + E_1^m X_1 + \dots + E_{m-1}^m X_{m-1} &= S_{m-1} \end{aligned}$$

Add the error magnitudes  $X_0$  through  $X_{m-1}$  to the symbol character values at the corresponding error locations  $E_0$  through  $E_{m-1}$  to correct the errors.

This algorithm, written in C, is available from AIM<sup>USA</sup> on the Data Matrix Developers Diskette, see Reference Document section.

*Annexe M (Normative)**ECC 200 Symbol Character Placement**M.1 Symbol Character Placement Program*

The following C language program generates symbol character placement diagrams:

```
#include <stdio.h>
#include <alloc.h>

int nrow, ncol, *array;

/* "module" places "chr+bit" with appropriate wrapping within array[] */
void module(int row, int col, int chr, int bit)
{ if (row < 0) { row += nrow; col += 4 - ((nrow+4)%8); }
  if (col < 0) { col += ncol; row += 4 - ((ncol+4)%8); }
  array[row*ncol+col] = 10*chr + bit;
}

/* "utah" places the 8 bits of a utah-shaped symbol character in ECC200 */
void utah(int row, int col, int chr)
{ module(row-2,col-2,chr,1);
  module(row-2,col-1,chr,2);
  module(row-1,col-2,chr,3);
  module(row-1,col-1,chr,4);
  module(row-1,col,chr,5);
  module(row,col-2,chr,6);
  module(row,col-1,chr,7);
  module(row,col,chr,8);
}

/* "cornerN" places 8 bits of the four special corner cases in ECC200 */
void corner1(int chr)
{ module(nrow-1,0,chr,1);
  module(nrow-1,1,chr,2);
  module(nrow-1,2,chr,3);
  module(0,ncol-2,chr,4);
  module(0,ncol-1,chr,5);
  module(1,ncol-1,chr,6);
  module(2,ncol-1,chr,7);
  module(3,ncol-1,chr,8);
}
void corner2(int chr)
{ module(nrow-3,0,chr,1);
  module(nrow-2,0,chr,2);
  module(nrow-1,0,chr,3);
  module(0,ncol-4,chr,4);
  module(0,ncol-3,chr,5);
  module(0,ncol-2,chr,6);
  module(0,ncol-1,chr,7);
  module(1,ncol-1,chr,8);
}
```

```

void corner3(int chr)
{ module(nrow-3,0,chr,1);
  module(nrow-2,0,chr,2);
  module(nrow-1,0,chr,3);
  module(0,ncol-2,chr,4);
  module(0,ncol-1,chr,5);
  module(1,ncol-1,chr,6);
  module(2,ncol-1,chr,7);
  module(3,ncol-1,chr,8);
}
void corner4(int chr)
{ module(nrow-1,0,chr,1);
  module(nrow-1,ncol-1,chr,2);
  module(0,ncol-3,chr,3);
  module(0,ncol-2,chr,4);
  module(0,ncol-1,chr,5);
  module(1,ncol-3,chr,6);
  module(1,ncol-2,chr,7);
  module(1,ncol-1,chr,8);
}

/* "ecc200" fills an nrow x ncol array with appropriate values for ECC200 */
void ecc200(void)
{ int row, col, chr;

/* First, fill the array[] with invalid entries */
  for (row=0; row<nrow; row++) {
    for (col=0; col<ncol; col++) {
      array[row*ncol+col] = 0;
    }
  }

/* Starting in the correct location for character #1, bit 8,... */
  chr = 1; row = 4; col = 0;

  do {
/* repeatedly first check for one of the special corner cases, then... */
    if ((row == nrow) && (col == 0)) corner1(chr++);
    if ((row == nrow-2) && (col == 0) && (ncol%4)) corner2(chr++);
    if ((row == nrow-2) && (col == 0) && (ncol%8 == 4)) corner3(chr++);
    if ((row == nrow+4) && (col == 2) && (!(ncol%8))) corner4(chr++);
/* sweep upward diagonally, inserting successive characters,... */
    do {
      if ((row < nrow) && (col >= 0) && (!array[row*ncol+col]))
        utah(row,col,chr++);
      row -= 2; col += 2;
    } while ((row >= 0) && (col < ncol));
    row += 1; col += 3;

/* & then sweep downward diagonally, inserting successive characters,... */
    do {

```

```

        if ((row >= 0) && (col < ncol) && (!array[row*ncol+col]))
            utah(row,col,chr++);
        row += 2; col -= 2;
    } while ((row < nrow) && (col >= 0));
    row += 3; col += 1;

/* ... until the entire array is scanned */
} while ((row < nrow) || (col < ncol));

/* Lastly, if the lower righthand corner is untouched, fill in fixed pattern */
if (!array[nrow*ncol-1]) {
    array[nrow*ncol-1] = array[nrow*ncol-ncol-2] = 1;
}
}

/* "main" checks for valid command line entries, then computes & displays array */
void main(int argc, char *argv[])
{ int x, y, z;

    if (argc <= 3) {
        printf("Command line: ECC200 #_of_Data_Rows #_of_Data_Columns\n");
    } else {
        nrow = ncol = 0;
        nrow = atoi(argv[1]); ncol = atoi(argv[2]);
        if ((nrow >= 6) && (~nrow&0x01) && (ncol >= 6) && (~ncol&0x01)) {
            array = malloc(sizeof(int) * nrow * ncol);

            ecc200();

            for (x=0; x<nrow; x++) {
                for (y=0; y<ncol; y++) {
                    z = array[x*ncol+y];
                    if (z == 0) printf(" WHI");
                    else if (z == 1) printf("BLK");
                    else printf("%3d.%d",z/10,z%10);
                }
                printf("\n");
            }
            free(array);
        }
    }
}

```

## M.2 Symbol Character Placement Rules

### M.2.1 Non-standard Symbol Character Shapes

Because the standard symbol character shape cannot always fit at the data module boundaries of the symbol and at some corners, a small set of non-standard symbol characters is required. There are six conditions: two boundary conditions which affect all symbol formats and four different corner conditions which apply to certain symbol formats:

- One portion of the symbol character shape is placed on one side and the other on the opposite side. This applies to two basic symbol character shapes (see Figure M1a). Variants of these arrangements concern the row to row relationship between the left and right hand boundary (see Table M1).
- One portion of the symbol character is placed on the top boundary and the other portion on the bottom boundary. This applies to two basic symbol character shapes (see Figure M1b). Variants of these arrangements concern the column to column relationship between the top and bottom boundary (see Table M1).
- Four symbol character shapes are split between two or three corners (see Figures M1c to M1f)

The non-standard symbol shapes are placed at opposite boundaries. The number of these pairings increases in general proportion to the size of the perimeter of the mapping matrix. The basic pattern

is as illustrated in Figures M1a and M1b. In Figure M1a, modules a8 and a7 are in the same row, as are modules b7 and b6. In Figure M1b module c6 and c3 are in the same column as are modules d3 and d1.

There are seven cases for boundary placement, which define the relative vertical position of the symbol characters illustrated in Figure M1a, the horizontal position of the symbol characters illustrated in M1b, and the corner conditions.

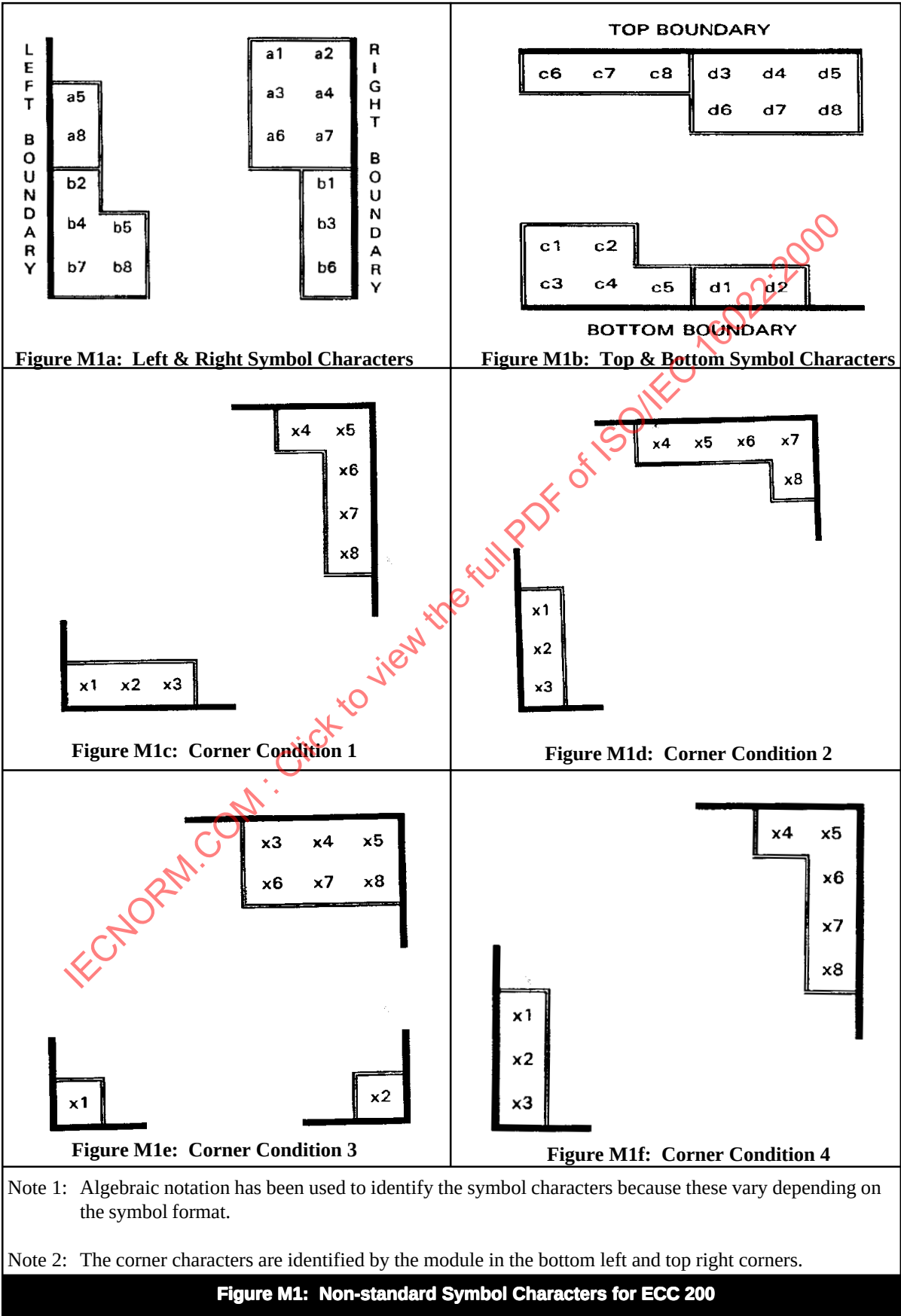
### M.2.2 Symbol Character Arrangement

The symbol characters are placed in a matrix in the following manner:

- A mapping matrix is created.
  - For small symbols with only one data region, this equates to the mapping matrix.
  - For larger symbols with more than one data region, the mapping matrix equates to an area the size of the abutted data regions. In effect, the mapping matrix has no separating alignment patterns. For example, the 36 x 36 format symbol has four 16 x 16 data regions which abut to create a mapping matrix 32 x 32. The size of the mapping matrix for each symbol format is given in Table 11. The boundary placement case is given in Table M1.
- Symbol character 2 is placed in the uppermost left position, with its modules conforming to the bit (or module) sequence defined in Figure 8. Using the notation 2.1 to identify module 1 of symbol character 2, this module is in the top row and leftmost column of every mapping

| Boundary Placement Case | Row Relationship of Module a8 and a7 | Column Relationship of Module c6 and c3 | Corner Condition Figure No. | Mapping Matrices Affected                                                                 | Refer to Annex M Figure No. for Example |
|-------------------------|--------------------------------------|-----------------------------------------|-----------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------|
| 1                       | a7 Row = a8 Row                      | c3 Column = c6 Column                   | None                        | Square: $8^2, 16^2, 24^2, 32^2, 40^2, 48^2, 56^2, 64^2, 72^2, 80^2, 88^2, 96^2, \& 120^2$ | Figure M4 & M11                         |
| 2                       | a7 Row = a8 Row - 2                  | c3 Column = c6 Column - 2               | None                        | Square: $10^2 \& 18^2$                                                                    | Figure M5 & M12                         |
| 3                       | a7 Row = a8 Row + 4                  | c3 Column = c6 Column + 4               | M1c                         | Square: $12^2, 20^2, 28^2, 36^2, 44^2, 108^2, \& 132^2$                                   | Figure M6 & M13                         |
| 4                       | a7 Row = a8 Row + 2                  | c3 Column = c6 Column + 2               | M1d                         | Square: $14^2 \& 22^2$                                                                    | Figure M7 & M14                         |
| 5                       | a7 Row = a8 Row                      | c3 Column = c6 Column + 2               | M1e                         | Rectangular: 6x16 & 14x32                                                                 | Figure M8                               |
| 6                       | a7 Row = a8 Row                      | c3 Column = c6 Column - 2               | None                        | Rectangular: 10x24 & 10x32                                                                | Figure M9                               |
| 7                       | a7 Row = a8 Row + 4                  | c3 Column = c6 Column + 2               | M1f                         | Rectangular: 6x28 & 14x44                                                                 | Figure M10                              |

**Table M1: Factors which Determine the Boundary Placement Cases**



|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| 2.1 | 2.2 | 3.6 | 3.7 | 3.8 | 4.3 | 4.4 | 4.5 |
| 2.3 | 2.4 | 2.5 | 5.1 | 5.2 | 4.6 | 4.7 | 4.8 |
| 2.6 | 2.7 | 2.8 | 5.3 | 5.4 | 5.5 |     |     |
| 1.a | 6.1 | 6.2 | 5.6 | 5.7 | 5.8 |     |     |
| 1.b | 6.3 | 6.4 | 6.5 |     |     |     |     |
|     | 6.6 | 6.7 | 6.8 |     |     |     |     |

Note: The values a and b depend on the size of the mapping matrix

**Figure M2: Starting Sequence for Module Placement**

matrix. The module array sequence shown in Figure M2 is constant for all mapping matrices.

3. The corner shapes are positioned according to Table M1 and the appropriate Figures M1c to M1f. Plotting of the standard symbol character shapes continues, nesting the shapes as illustrated above for symbol characters 2, 5, and 6. The non-standard symbol characters are positioned as per Table M1. This process results in the mapping matrix being completely covered in symbol characters, most of which are un-numbered.
4. The sequence of symbol characters is determined as follows. Symbol characters are arranged on 45 degree parallel diagonal lines between the lower left and upper right, generally linking through the centers on module 8.
5. The first diagonal line starts with the line through module 8 of symbol character 1; this is module 8 except in the case of the 6 x 28 mapping matrix, where the corner condition, as defined in Figure M1f, determines the values of modules in symbol character 1 (i.e. making 1.b equal 1.2). The diagonal line continues through modules 2.8 and 3.8.
6. At this point, the diagonal line crosses the top row boundary. The next diagonal line is started 4 modules to the right in the top row, or

in the case of the 8 x 8 mapping matrix, 3 modules right and 1 module down; i.e. the diagonal line is always displaced by 4 modules. Symbol characters are numbered in order, based on the placement path crossing module 8. Thus the next characters are determined by the downward diagonal line crossing modules 4.8, 5.8, 6.8 and so on.

7. As shown in Figure M3, the placement path continues as diagonal lines four modules to the right (or four modules down, or combinations thereof) from the previous diagonal line. The first, and all odd numbered, diagonal lines map the symbol character sequence from bottom left to top right. The second, and all even numbered, diagonal lines map the symbol character sequence from the top right to the bottom left.
8. When the placement path encounters a non-standard symbol character shape, which is not completely contained within the boundaries of the mapping matrix, that symbol character is continued on the opposite side of the matrix. This has the effect of numbering the opposite portions of these symbol characters before the placement path crosses that position. For example, in the illustrated mapping matrix (see Figure M3) the other portions of symbol character 3 and 7 are pre-numbered before the placement path crosses them. Thus the placement path only numbers un-numbered symbol characters. These boundary and

corner conditions are specified in Table M1. This can be seen in Figure M3 for symbol characters 1, 3, 4, and 7.

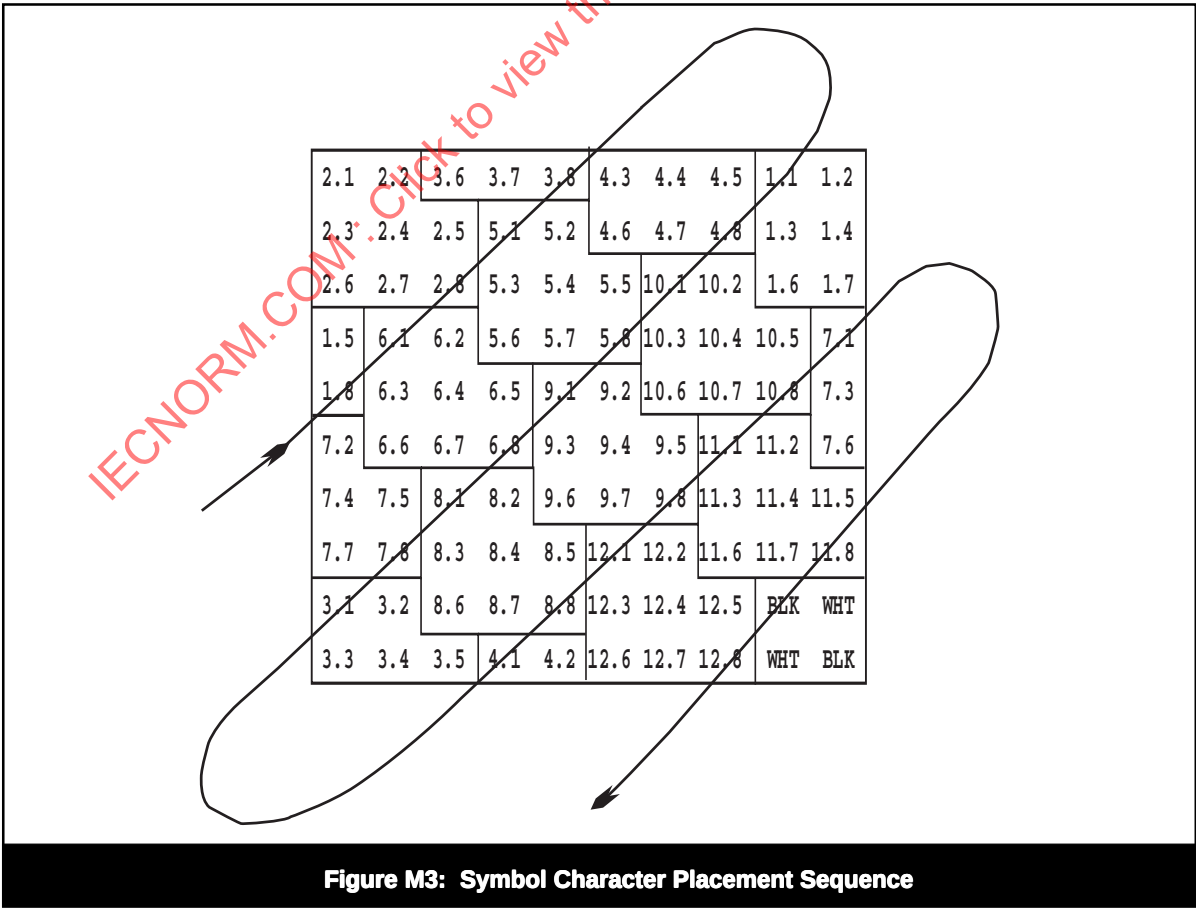
The corner conditions also affect the numbering sequence. The bottom left corner as illustrated in:

- Figure M1c is numbered immediately before the symbol character above it (see Figures M6 and M13 for examples).
- Figure M1d is numbered immediately before the symbol character above it (see Figure M7 and M14 for examples).
- Figure M1e is numbered immediately after the symbol character to its right (see Figure M8 for an example).
- Figure M1f is numbered immediately before the symbol character above it (see Figure M10 for an example).

The remaining modules of the corner are numbered before the placement path crosses them.

- 9. The placement procedure continues until all symbol characters are placed, and it ends in the lower right of the mapping matrix. Four sizes of mapping matrix (10 x 10, 14 x 14, 18 x 18, and 22 x 22) have a 2 x 2 area remaining in the bottom right hand corner. The top left and bottom right modules of this area are dark (nominally encoding binary 1). This is illustrated in Figure M3.

Typical mapping matrices conforming to this procedure are illustrated in Annexe M.3. Figures M4 to M10 cover respective cases 1 to 7 for boundary placement. Figure M11 to M14 are another set of examples for cases 1 to 4. Annexe M.1 provides a C language program capable of mapping all encoded bits into the appropriate mapping matrix.



### M.3 Symbol Character Placement Examples for ECC 200

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| 2.1 | 2.2 | 3.6 | 3.7 | 3.8 | 4.3 | 4.4 | 4.5 |
| 2.3 | 2.4 | 2.5 | 5.1 | 5.2 | 4.6 | 4.7 | 4.8 |
| 2.6 | 2.7 | 2.8 | 5.3 | 5.4 | 5.5 | 1.1 | 1.2 |
| 1.5 | 6.1 | 6.2 | 5.6 | 5.7 | 5.8 | 1.3 | 1.4 |
| 1.8 | 6.3 | 6.4 | 6.5 | 8.1 | 8.2 | 1.6 | 1.7 |
| 7.2 | 6.6 | 6.7 | 6.8 | 8.3 | 8.4 | 8.5 | 7.1 |
| 7.4 | 7.5 | 3.1 | 3.2 | 8.6 | 8.7 | 8.8 | 7.3 |
| 7.7 | 7.8 | 3.3 | 3.4 | 3.5 | 4.1 | 4.2 | 7.6 |

**Figure M4: Codeword Placement for Square Mapping Matrix of size 8**

|     |     |     |     |     |      |      |      |      |      |
|-----|-----|-----|-----|-----|------|------|------|------|------|
| 2.1 | 2.2 | 3.6 | 3.7 | 3.8 | 4.3  | 4.4  | 4.5  | 1.1  | 1.2  |
| 2.3 | 2.4 | 2.5 | 5.1 | 5.2 | 4.6  | 4.7  | 4.8  | 1.3  | 1.4  |
| 2.6 | 2.7 | 2.8 | 5.3 | 5.4 | 5.5  | 10.1 | 10.2 | 1.6  | 1.7  |
| 1.5 | 6.1 | 6.2 | 5.6 | 5.7 | 5.8  | 10.3 | 10.4 | 10.5 | 7.1  |
| 1.8 | 6.3 | 6.4 | 6.5 | 9.1 | 9.2  | 10.6 | 10.7 | 10.8 | 7.3  |
| 7.2 | 6.6 | 6.7 | 6.8 | 9.3 | 9.4  | 9.5  | 11.1 | 11.2 | 7.6  |
| 7.4 | 7.5 | 8.1 | 8.2 | 9.6 | 9.7  | 9.8  | 11.3 | 11.4 | 11.5 |
| 7.7 | 7.8 | 8.3 | 8.4 | 8.5 | 12.1 | 12.2 | 11.6 | 11.7 | 11.8 |
| 3.1 | 3.2 | 8.6 | 8.7 | 8.8 | 12.3 | 12.4 | 12.5 | BLK  | WHT  |
| 3.3 | 3.4 | 3.5 | 4.1 | 4.2 | 12.6 | 12.7 | 12.8 | WHT  | BLK  |

**Figure M5: Codeword Placement for Square Mapping Matrix of size 10**

|     |     |      |      |      |      |      |      |      |      |      |      |
|-----|-----|------|------|------|------|------|------|------|------|------|------|
| 2.1 | 2.2 | 3.6  | 3.7  | 3.8  | 4.3  | 4.4  | 4.5  | 13.1 | 13.2 | 8.4  | 8.5  |
| 2.3 | 2.4 | 2.5  | 5.1  | 5.2  | 4.6  | 4.7  | 4.8  | 13.3 | 13.4 | 13.5 | 8.6  |
| 2.6 | 2.7 | 2.8  | 5.3  | 5.4  | 5.5  | 12.1 | 12.2 | 13.6 | 13.7 | 13.8 | 8.7  |
| 1.5 | 6.1 | 6.2  | 5.6  | 5.7  | 5.8  | 12.3 | 12.4 | 12.5 | 14.1 | 14.2 | 8.8  |
| 1.8 | 6.3 | 6.4  | 6.5  | 11.1 | 11.2 | 12.6 | 12.7 | 12.8 | 14.3 | 14.4 | 14.5 |
| 7.2 | 6.6 | 6.7  | 6.8  | 11.3 | 11.4 | 11.5 | 15.1 | 15.2 | 14.6 | 14.7 | 14.8 |
| 7.4 | 7.5 | 10.1 | 10.2 | 11.6 | 11.7 | 11.8 | 15.3 | 15.4 | 15.5 | 1.1  | 1.2  |
| 7.7 | 7.8 | 10.3 | 10.4 | 10.5 | 16.1 | 16.2 | 15.6 | 15.7 | 15.8 | 1.3  | 1.4  |
| 9.1 | 9.2 | 10.6 | 10.7 | 10.8 | 16.3 | 16.4 | 16.5 | 18.1 | 18.2 | 1.6  | 1.7  |
| 9.3 | 9.4 | 9.5  | 17.1 | 17.2 | 16.6 | 16.7 | 16.8 | 18.3 | 18.4 | 18.5 | 7.1  |
| 9.6 | 9.7 | 9.8  | 17.3 | 17.4 | 17.5 | 3.1  | 3.2  | 18.6 | 18.7 | 18.8 | 7.3  |
| 8.1 | 8.2 | 8.3  | 17.6 | 17.7 | 17.8 | 3.3  | 3.4  | 3.5  | 4.1  | 4.2  | 7.6  |

**Figure M6: Codeword Placement for Square Mapping Matrix of size 12**