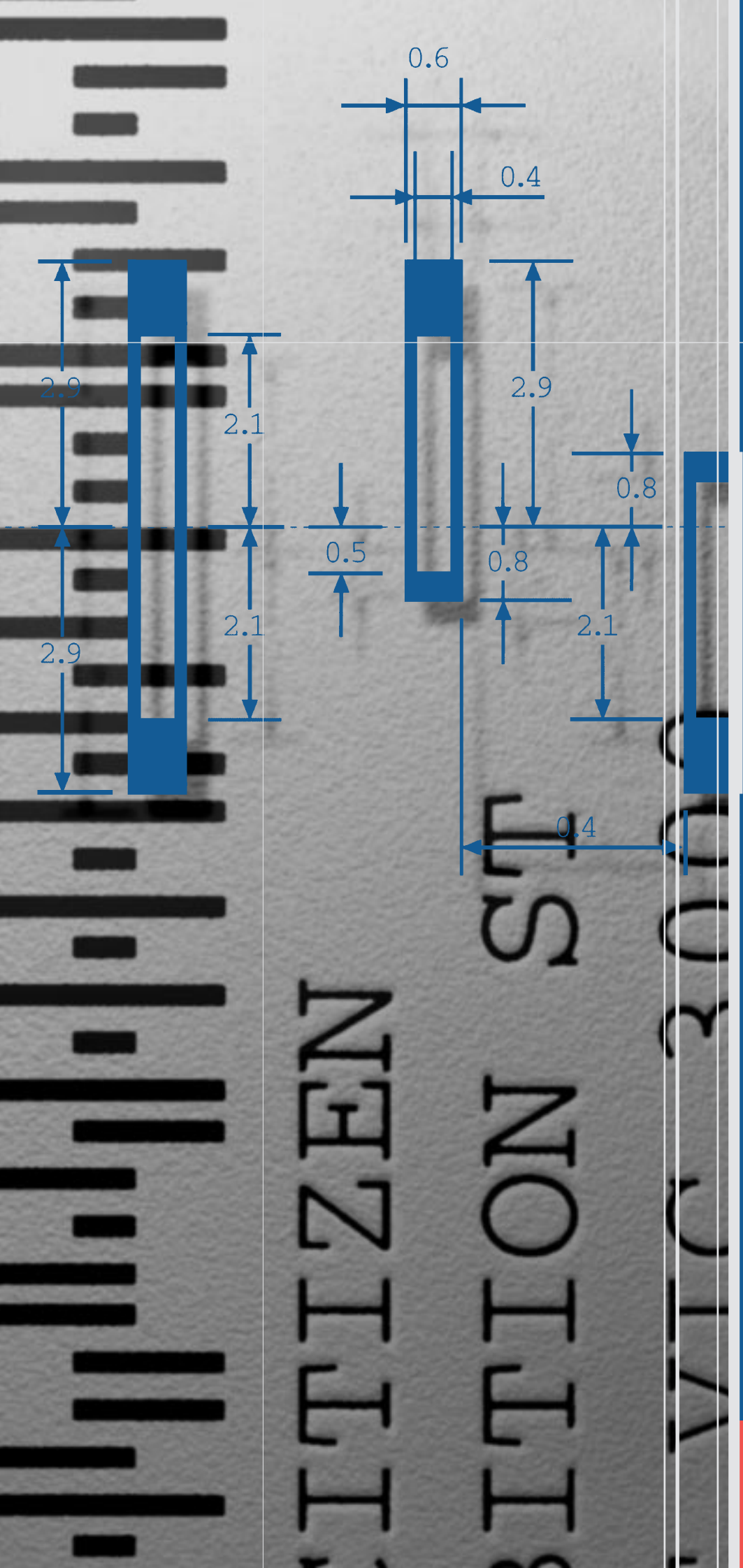
A Guide to Printing the 4-State Barcode



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Introduction

This document is primarily to provide information for software developers on the creation and printing of barcodes. It describes the symbology, format, fields, values and other characteristics of the Australia Post 4-State Customer Barcodes.

This document is intended to be read in conjunction with the Australia Post Customer Barcoding Technical Specifications document, released in June 1998. Reference tables (ie. Encoding N table) are reproduced directly from that document and are attached in the Appendix.

Australia Post Overview

Australia Post is investing $500m on upgrading its mail processing network. Part of this project calls for the installation of new Barcode Sorters (BCS) at mail centres to increase sort rates through mechanisation and allow the introduction of deep sorting. These BCS machines will be capable of sorting incoming mail via a barcode read from letters.

To implement the new Customer barcoding system for letters, Australia Post has developed the Postal Address File (PAF), which contains 8.8 million physical delivery points in Australia. Australia Post has allocated a unique eight digit Delivery Point Identifier (DPID)to each of these delivery addresses within Australia.

The DPID will be encoded to form the main component of the customer barcode. It will be printed in barcode format by customers on their letters as part of an address.

Prerequisites to printing the barcode

The production of barcoded mail by a customer is the final step of a three-stage Quality Addressing process:

1. Modify Customer Databases to append the DPID
2. Validation of Address Information
3. Printing the Barcode

Appending the DPID

The first step in quality addressing is to identify and modify customer databases to store the DPID as a fixed and mandatory part of the address file structure for each record. As mentioned previously, the DPID is 8 digits in length.

Validation of Address Information

Customers will need to access approved address matching and correction software which incorporates the PAF. Software will be available from authorised third party suppliers. Several software solutions will be available from which customers can choose the one that best suits their business requirements and budget. Using this software, customers will validate and correct the address information in their customer database against the PAF. The software will append the DPID to its newly created field within the record.

There are two alternatives for customers to append the DPID to address databases:

1. Append the DPID internally; or
2. Send mailing lists to a bureau service, who will append the DPID

Print the Barcode

As a final step, customers will be able to convert the DPID into a barcode and print it as part of the address. As well, letters will be required to be sorted and presented to meet new presort plan specifications.

The key prerequisite to printing barcodes is to have a mailing list with every record containing its associated DPID value. Optional customer information, such as a customer identifier or campaign number, may also be included for each record and encoded into the barcode.

The generation and printing of 4-State barcodes will be expanded throughout the remainder of this document.

An Overview of the Barcode

The barcode adopted by Australia Post is known as the 4-State barcode. This barcode comprises four types of bars (the four states), each of which has a distinct name, value and barcode symbol. The four states are shown in Figure 1 and their values defined in Table 1.

The generation of the barcode initially focuses on creating a string representation of the barcode containing Bar State values. As a final step, the string of Bar State values are printed as their associated barcode characters.

It has previously been mentioned that the main component of the barcode is the Delivery Point Identifier (DPID). Around the encoding of the DPID, a number of other elements are added to the customer barcode to provide greater barcode robustness and introduce the option of customers encoding their own business information. Each barcode contains the following bars and fields:

1. Start bars
2. Format Control Code Field
3. Sorting Code Field (DPID)
4. Customer Information Field (some formats only)
5. Filler Bar
6. Reed Solomon Error Correction Parity values
7. Stop Bars

There are three customer barcode structures; the inclusion of customer information being allowed in two bar types:

Standard Customer Barcode 1 - length 37 bars, no bars of customer information

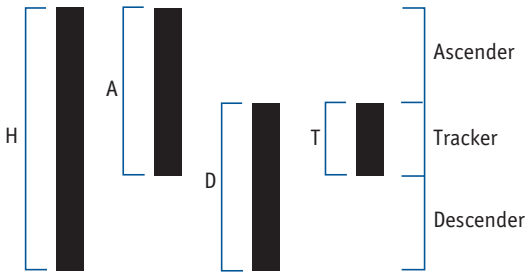
Customer Barcode 2 - length 52 bars, 16 bars of customer information

Customer Barcode 3 - length 67 bars, 31 bars of customer information

The structure of the 67 bar length customer barcode is shown in Figure 2.

Further detailed information on customer barcodes is available from the Customer Barcoding Technical Specifications document.

Figure 1

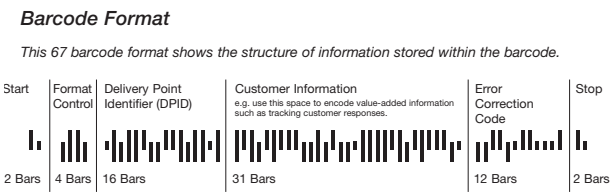


The four states of the barcode

Bar	Elements	Bar State Value
T	Tracker	3
D	Tracker, Descender	2
A	Tracker, Ascender	1
H	Tracker, Ascender, Descender	0

Table 1. 4-State Barcode Values

Figure 2



Sample Customer Barcode Structure

Generating and Printing the Barcode

There are 4 major steps involved in printing the barcode:

1. Convert each digit of the FCC, DPID and customer information fields into their Bar State values

2. Generating and appending Reed Solomon error correction bars

3. Add the Start and Stop Bars

4. Printing the barcode.

It should be emphasised that it is not mandatory for customer information to be present in the barcode. The presence of customer information would be indicated by the appropriate format control code.

Step 1. Converting the FCC, DPID and Customer Information fields

There are currently 14 defined format control codes for 4-State barcodes. Of these codes, customers will mainly be concerned with the following 3 types as shown in Table 2:

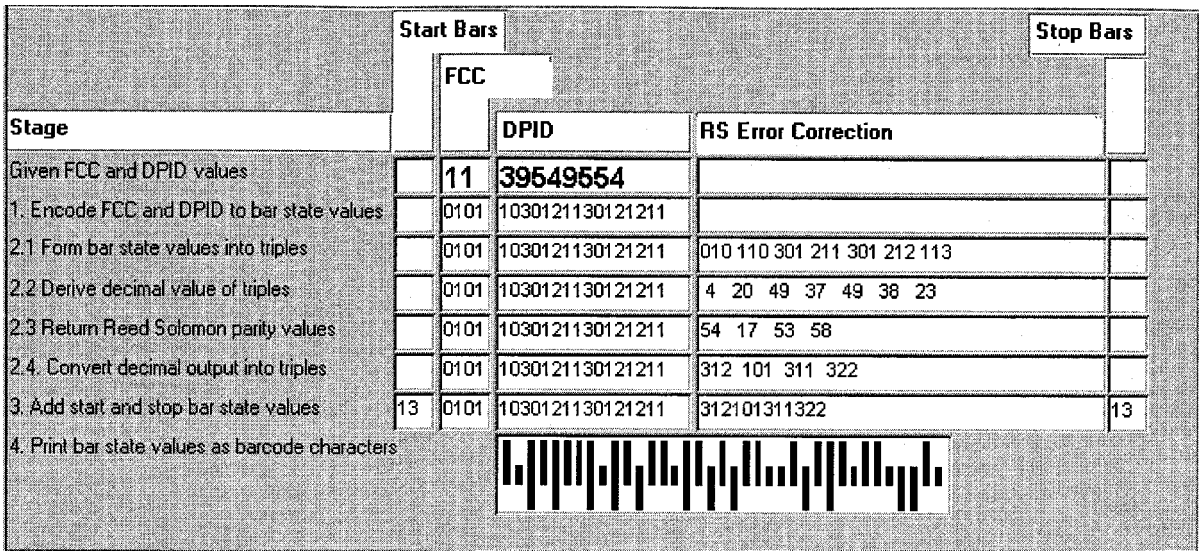
Value	Format	Length (bars)
11	Standard Customer Barcode	37
59	Customer Barcode 2	52
62	Customer Barcode 3	67

Table 2. Format Control Codes

Once the appropriate format control code is selected, each digit of the FCC and the DPID is then encoded using the N table (see Appendix) into its Bar State value representation. Two Bar State values are encoded from each FCC and DPID digit.

An example of generating a barcode is shown below in Figure 3. The barcode is 37 bars in length and the DPID used has a value of 39549554.

Figure 3



Generation of a 37 bar length barcode

For 52 and 67 bar length customer barcodes, customer information may also be represented by a string of valid Bar State values. This string is free format, and may be generated using customer specific algorithms. If the customer information generated is less than 16 or 31 bars, the remainder of the customer information field is padded with filler bars (bar value of 3).

Customer information can be generated from either the N or C encoding tables (see Appendix), or using proprietary techniques. Using the N table, a digit may be represented as two Bar State values. Using the C table, a character (upper case, lower case, numeric and some special characters) may be represented as three Bar State values. Using Australia Post supplied encoding tables, Table 3 shows the maximum amount of customer information that can be held by the customer information field for various barcode formats.

Barcode Type	**Customer Information Field Length**	**Max. Info** (N table)	**Max. Info** (C table)
Standard Customer Barcode 37 Bars	0 Bars	N/a	N/a
Customer Barcode 2 52 Bars	16 Bars	8 digits	5 characters
Customer Barcode 3 67 Bars	31 Bars	15 digits	10 characters

Table 3. Storage capacity of the Customer Information field

An example of the use of customer information is shown in Figure 4. Generation of a 52 bar length barcode, using the Customer Barcode 2 format, a DPID of 56439111 and customer information of *ABA 9*. This customer information is encoded using the C table (see Appendix) and results in 15 Bar State values. Note that a filler bar is used to space the customer information to 16 bars.

Figure 4

Stage	Start Bars	FCC	DPID	Customer Info	RS Error Correction	Stop Bars
Given FCC, DPID and Customer Information		59	56439111	ABA 9		
1. Encode FCC, DPID and Customer Info		1230	1220111030010101	0000010000033223		
2.1 Form bar state values into triples		1230	1220111030010101	0000010000033223	123 012 201 110 300 101 010 000 010 000 033 223	
2.2 Derive decimal value of triples		1230	1220111030010101	0000010000033223	27 6 33 20 48 17 4 0 4 0 15 43	
2.3 Return Reed Solomon parity values		1230	1220111030010101	0000010000033223	52 25 0 61	
2.4. Convert decimal output into triples		1230	1220111030010101	0000010000033223	310 121 000 331	
3. Add start and stop bar state values	13	1230	1220111030010101	0000010000033223	310121000331	13
4. Print bar state values as barcode characters						

Generation of a 52 bar length barcode

Step 2. Reed Solomon Error Correction

Reed Solomon error correction is a particular implementation of error correction that has found widespread application, and it is the system that Australia Post will use to maximise the read rate of barcoded address information. The Reed Solomon algorithm is mathematical, and no attempt is made here to explain the mathematics. The approach taken is to explain the sequence of actions to be performed.

Reed Solomon error correction is used to improve the robustness of the customer barcode and provides the ability to correct problems via the following formula:

$2E + e <= 4$

where E = errors

and e = erasures

Examples of the Reed Solomon algorithm have been provided in various programming codes, namely Visual Basic, ANSI C and COBOL. These programming codes may be downloaded from the Australia Post web site (Future Post mini—site), located at www.auspost.com.au/futurepost. Whilst Australia Post provides these programs in good faith, no responsibility is taken as to their accuracy. The programs are provided for guidance only.

There are four steps to generating Reed Solomon error correction information:

1. Form Bar State values into triples
2. Derive the decimal value of triples
3. Return Reed Solomon parity decimal values
4. Convert the decimal parity values into triples

Step 2·1. Form Bar State values into triples

Initially, the string of Bar State values generated from the encoding of the FCC, DPID and customer information is grouped into triples. Because the standard barcode (FCC = 11) has a string length of only 20 (4 from the FCC and 16 from the DPID), a filler bar with a Bar State value of 3 is appended.

The customer information Bar State values are also used as an input to the generation of Reed Solomon error correction values, as shown below in Table 4.

Barcode Type	Length	Reed Solomon Input	R/S Input Length	R/S Input Triples	R/S Output Triples
Standard Customer Barcode	37 Bars	FCC, DPID	21 Bars, incl. one filler	7	4
Customer Barcode 2	52 Bars	FCC, DPID, Customer Information	36 Bars	12	4
Customer Barcode 3	67 Bars	FCC, DPID, Customer Information	51 Bars	17	4

Table 4. Reed Solomon Inputs

In all circumstances, the Reed Solomon algorithm returns 4 parity values, which are converted into 12 Bar States.

Step 2·2. Derive the decimal value of triples

These triples are then treated as base 4 numbers (consisting of 0,1,2,3 and in contrast to binary, octal or hexadecimal) and converted into their decimal value using the Bar-to-Decimal encoding table (see Appendix).

Step 2·3. Return the Reed Solomon parity decimal values

The Reed Solomon algorithm takes the decimal representation of the Bar State triples as inputs, and produces four decimal parity values as output.

The Reed Solomon algorithm follows a common approach for generating the parity values. An illustration is provided here. The illustration is not rigorous mathematically.

The decimal values of the information triples are used as co-efficients for an information polynomial which is divided by a generator polynomial. The division process produces a result and a remainder polynomial called the parity polynomial. The parity polynomial is added to the information polynomial to form the codeword polynomial. If this is divided by the generator polynomial it should produce a remainder of zero. If the remainder is non-zero, then some corruption of the codeword has occurred and a correction must be applied.

For the purposes of verifying the accuracy of implementing the Reed Solomon algorithm, test information is provided in Table 5. The information incorporates all necessary inputs for the Reed Solomon algorithm and its returned parity values.

Barcode FCC	No. of Barcode Bars	DPID	Customer Information*	Reed Solomon Parity Values			
11	37	39987520		50	25	52	50
11	37	67671415		35	61	29	12
11	37	48487312		57	13	12	25
11	37	35797531		36	11	25	2
59	52	32211324	A124B	26	23	20	52
59	52	77665544	C A P	7	61	53	1
59	52	56439111	ABA 9	52	25	0	61
59	52	61295478	C8	7	20	45	46
62	67	82224535	555439	14	57	58	28
62	67	79438541	AaaB 155	24	21	28	51
62	67	43289421	CAM Num 20	1	27	61	45
62	67	52123970	12AA12bb	14	32	3	11

Table 5 – Reed Solomon Algorithm Test Data

**** C Encoding Table used for customer information.***

Step 2·4. Convert the decimal parity values into triples

The Reed Solomon algorithm returns four parity values. These parity values are converted from their decimal value into their base 4 representation (via the Bar—to—Decimal encoding table), forming a string of 12 Bar State values. These Bar State values are appended to the end of the existing Bar State values string.

Step 3. Adding Start and Stop Bars

The start and stop bars are two bars in length and have Bar State values of 1 and 3 respectively. As mentioned in the Customer Barcoding Technical Specifications document, these bars ensure the barcode is read the right way around, even when the barcode is upside down.

With the four start and stop bars added, the customer barcode is now completed as a string of Bar State values.

Step 4. Printing the Barcode Characters

With the creation of the string of Bar State values now complete, it finally remains for the string to be converted to their respective barcode character equivalents and printed.

Printing essentially involves sending a stream of characters (representing the records from the address list with the string of Bar State values) from the computer to a printing device, and printer s electronics converts the character stream to the printed output on the mail piece. In this character stream, the string of Bar State values will be marked appropriately, thus notifying the printer to load an appropriate font type, different from the human-readable address characters, to print the barcode characters. The printing device needs to be able to recognise the string of Bar State values and convert them to their associated barcode characters.

It is envisaged that the barcode characters will be capable of being printed, to meet Australia Post technical specifications and quality requirements, by a number of different printer technologies. These include dot matrix, inkjet and laser printers.

For laser printers, it is necessary to load a font incorporating the barcode characters before printing mail pieces. This font can be obtained in many ways, for example:

Downloaded from application software into printer memory

Resident on the computer in firmware
(ie. On a SIMM/ DIMM card)

Some customers may be unable to generate the string of Bar State values. In this case, there are two alternatives available to print barcode characters:

1. Send mailing information, including the DPID to the printer, which will have the generating logic inbuilt to convert the DPID to its Bar State values and then to the associated barcode characters.
2. Capture the stream of characters being sent to the printer by a separate application, which will convert the DPID to its associated Bar State values, before passing the altered print stream to a printer.

With the font loaded, the mail piece will be printed with the address incorporating a customer barcode.

Appendix

Barcode Encoding/ Conversion Tables

Bar to Decimal Conversion Table

Decimal Value	Bar Value	Decimal Value	Bar Value
0	000	32	200
1	001	33	201
2	002	34	202
3	003	35	203
4	010	36	210
5	011	37	211
6	012	38	212
7	013	39	213
8	020	40	220
9	021	41	221
10	022	42	222
11	023	43	223
12	030	44	230
13	031	45	231
14	032	46	232
15	033	47	233
16	100	48	300
17	101	49	301
18	102	50	302
19	103	51	303
20	110	52	310
21	111	53	311
22	112	54	312
23	113	55	313
24	120	56	320
25	121	57	321
26	122	58	322
27	123	59	323
28	130	60	330
29	131	61	331
30	132	62	332
31	133	63	333

Encoding Tables

C Encoding Table			
Character	Bar Value	Character	Bar Value
A	000	a	023
B	001	b	030
C	002	c	031
D	010	d	032
E	011	e	033
F	012	f	103
G	020	g	113
H	021	h	123
I	022	i	130
J	100	j	131
K	101	k	132
L	102	l	133
M	110	m	203
N	111	n	213
O	112	o	223
P	120	p	230
Q	121	q	231
R	122	r	232
S	200	s	233
T	201	t	303
U	202	u	313
V	210	v	323
W	211	w	330
X	212	x	331
Y	220	y	332
Z	221	z	333
0	222	Space	003
1	300	#	013
2	301		
3	302		
4	310		
5	311		
6	312		
7	320		
8	321		
9	322		

N Encoding Table	
Number	Bar Value
0	00
1	01
2	02
3	10
4	11
5	12
6	20
7	21
8	22
9	30