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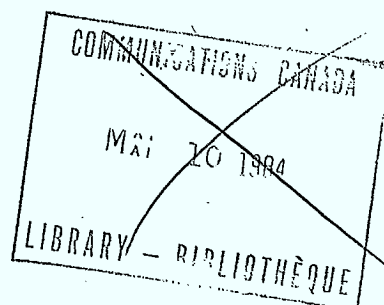
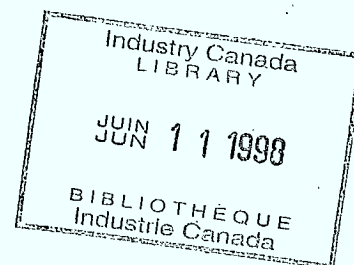
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/TELIDON APPLICATIONS STUDY/

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REFERENCES

- 1 Videotex Terminals
International Information Exchange for Interactive Videotex
CCITT Recommendation S.100
- 2 Public Facsimile Service
General Operational Provisions for the International Public Facsimile
Services
CCITT Recommendation F.160
- 3 Standardization of Group 3 Facsimile Apparatus for Documentation
Transmission
CCITT Recommendation T.4
- 4 Videotex Service
CCITT Recommendation F.300
- 5 Code Extension Techniques for Use with ISO 7-bit Coded Character Set
ISO 2022-1973 (E)
- 6 7-bit Coded Character Set for Information Processing Interchange
ISO 646-1973 (E)
- 7 Information Processing - 8-bit Coded Character Set for Information
Interchange
ISO 4873-1979 (E)
- 8 Videotex Presentation Layer Protocol - Draft 1
CCITT contribution #82 - Study Group III
- 9 Videotext/Teletext Presentation Protocol Syntax (North American PLPS)
T500.X3L2/82-96
ANSI/CSA
- 10 Telidon - Videotex Presentation Level Protocol: Augmented Picture
Description Instructions
CRC Technical Note # 709-E
- 11 Presentation Level Protocol Videotex Standard
Bell System May 1981
- 12 Comparison of Redundancy Codes for Facsimile Transmission of Documents
Hans Georg Musmann and Dieter Preuss
IEEE Transactions on Communications Volume COM-25 No. 11 November 1977
- 13 Videotex Looks Right as Development Mounts
Harvey J. Hindin
Electronics August 25, 1982
- 14 Printers Prepare for a Colorful Future
Edward Connolly
Electronic Design

REFERENCES (Continued)

- 15 Color Graphic Printers Slip into Computer Systems
Stuart Cox
Electronic Design May 27, 1982
- 16 A comparison of Antialiasing Techniques
Franklin C. Crow
IEEE C G & A January 1981
- 17 Filtering Edges for Grey-Scale Displays
Satish Gupta, Robert F. Sroull
Computer Graphics Volume 15 Number 3 August 1981
- 18 Information Processing - Coded Character Sets for Text Communication
Parts 1, 2 and 3
ISO/TC97/SC2 N1254 N1255 N1256
- 19 Teletex service
CCITT Recommendation F.200
- 20 Teletex Terminals
Terminal Equipment for Use in the Teletex Service
CCITT Recommendation S.60
- 21 Text Communication Registration of Graphic Character Subrepertories
ISO TC97/SC2 N1260
- 22 Report of the Meeting of Working Parties VIII/2, 3 and 4, Miami 7-11
June 1982 the Period 1981-1984
International Telegraph and Telephone Consultative Committee CCITT
- 23 Information Processing - ISO 7-bit and 8-Bit Coded Character Sets -
Code Extension Techniques
ISO/DIS 2022.2
- 24 Operating Methods for the International Public Telegram Service
Operational Provisions for the International Public telegram Service
CCITT Recommendation F.1
- 25 Conversion Between International Telegraph Alphabet No.2 and Alphabet
No. 5
CCITT Recommendation S.18
- 26 Raster to Polygon Conversion of Images
by Seymour Shlien
Department of Communications
- 27 Character Repertoire and Coded Character Sets for the International
Teletex Service
CCITT Recommendation S.61

REFERENCES (Continued)

- 28 Information Processing - ISO 7-bit and 8-bit Character Sets -
Additional Control Functions for Character-imaging Devices
ISO/DIS 6429.2
- 29 Solid State Radio Engineering
H.L.Krauss, C.W.Bastian, F.H.Raab
pp 334-340
John Wiley & Sons 1980
- 30 Operational Provisional for the International Public Facsimile Service
Between Public Bureaux (Bureaufax)
CCITT Recommendation F.170
- 31 Principles of Interactive Computer Graphics
Second Edition
by William M. Newman and Robert F. Sproull
McGraw-Hill Book Company 1979
- 32 Fundamentals of Interactive Computer Graphics
by James D. Foley and Andries Van Dam
Addison Wesley 1982

INTRODUCTION

This is the final report on a study commissioned by the Department of Communications (DSS File #2ER.36100.2-4366) to develop protocol transformation algorithms to permit Telidon terminals conforming to CSA-T500 Standard, to receive and display documents communicated via other Telimatic systems. The study also includes developments of code conversion algorithms between Telidon 7 bit and 8 bit environments.

This report is divided into five sections: Section 1 discusses the transformation algorithms required to transform 7-bit Telidon protocol to 8-bit Telidon and vice versa. Section 2 discusses the transformation algorithms required to permit a Telidon terminal or data base to access Telitex services by being able to transmit and receive alphanumeric documents conforming to the Telitex standards. Section 3 discusses the transformation algorithm required to permit a Telidon terminal or data base to transmit information to Group 3 and 4 facsimile terminals. Section 4 discusses the transformation algorithms required to permit a Telidon terminal or data base to receive information from Group 3 or Group 4 facsimile terminals. Section 5 proposes methods by which hard copy can be generated with a Telidon system.

1. 7-BIT TO 8-BIT CONVERSION

Telidon was first devised as a 7-bit coding scheme to represent character or graphical data. The eighth bit (most significant bit) was free to be used for parity checking during data communication.

The trend in communication networks is more towards packet formats where parity and error checking codes are appended to the data bytes. This format allows a full eight bit wide data byte, with resulting increase in information content. Videotex developments will mirror this development in communication techniques. As discussed in more detail below, the Telidon coding scheme still remains essentially a 7-bit coding scheme. However, the eighth bit doubles the size of the coding table in the receiving terminal, and reduces significantly the requirement to resort to extension techniques in order to increase the character address space.

Teletex, on the other hand, is restricted to a 7-bit environment under the BSI4 broadcast specification. The eighth bit is used to set odd parity on each transmitted data byte. This communication scheme is a reflection of the inherently noisier transmitting environment and the higher error rates to be expected in over-the-air broadcasting.

Telidon data bases will continue to be developed for both 7-bit and 8-bit transmission modes. In keeping with the design objectives of Telidon an easy facility to transform from one mode to the other is very desirable. The problem of providing such a facility is addressed by the algorithm presented below.

1.1 CODE EXTENSION TECHNIQUES

At the presentation level, Telidon uses 7-bit character codes to represent data that consists of text or graphic items. The coding format is illustrated in Figure 1-1.

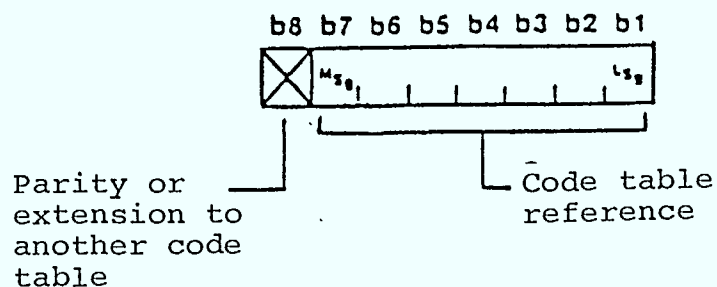


Figure 1-1 Telidon 7-bit coding format

The 7-bit code is an index into a location in a 128 position code table. This code table is normally represented as a table of eight columns and 16 rows with bits B7, B6, B5 addressing the columns and bits B4, B3, B2 and B1 addressing the rows (Figure 1-2).

Entries in the Table are represented by either giving the 7-bit address or by specifying the position coordinates in the format.

Column/Row

E.G.

2/1 refers to the position with address octal 41

6/7 refers to the position with address octal 147

A 7-bit code is obviously limited to an 128 size address space. In order to extend the address space, Telidon uses the code extension techniques presented in the ISO International Standard 2022 (Reference 23). The 128 position code table is segmented into two sections. The first segment, columns 1 and 2, is reserved for a set of 32 control characters called the C0 set. The remaining columns define a 96 character set called the G table. Escape sequences are specified that allow the loading and switching of different 96 character sets into the G table. The actual loading of a character set into the G table may be regarded as a two stage process: first, a character set is designated from a repertory of character sets into one of the four tables labelled G0, G1, G2 and G3. This is done via an escape sequence. Next, another escape sequence (or shift function) then invokes the labelled table into the G table. The complete scheme is illustrated in Figure 1-3.

The shift functions S1, S0 occur in the C0 control set. All the other shift functions have the format:

ESC Fs

where Fs is an entry from column 6 in the code table. Escape sequences are generally three character sequences of the form

ESC I F

Where ESC = 1/11

I = Entry in Column 2

F = Entry from Columns 4, 5, 6 or 7

These expansion techniques extend almost indefinitely the size of the character set repertory, while still working with a 128 size address space.

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7-Bit to 8-Bit Telidon Conversion

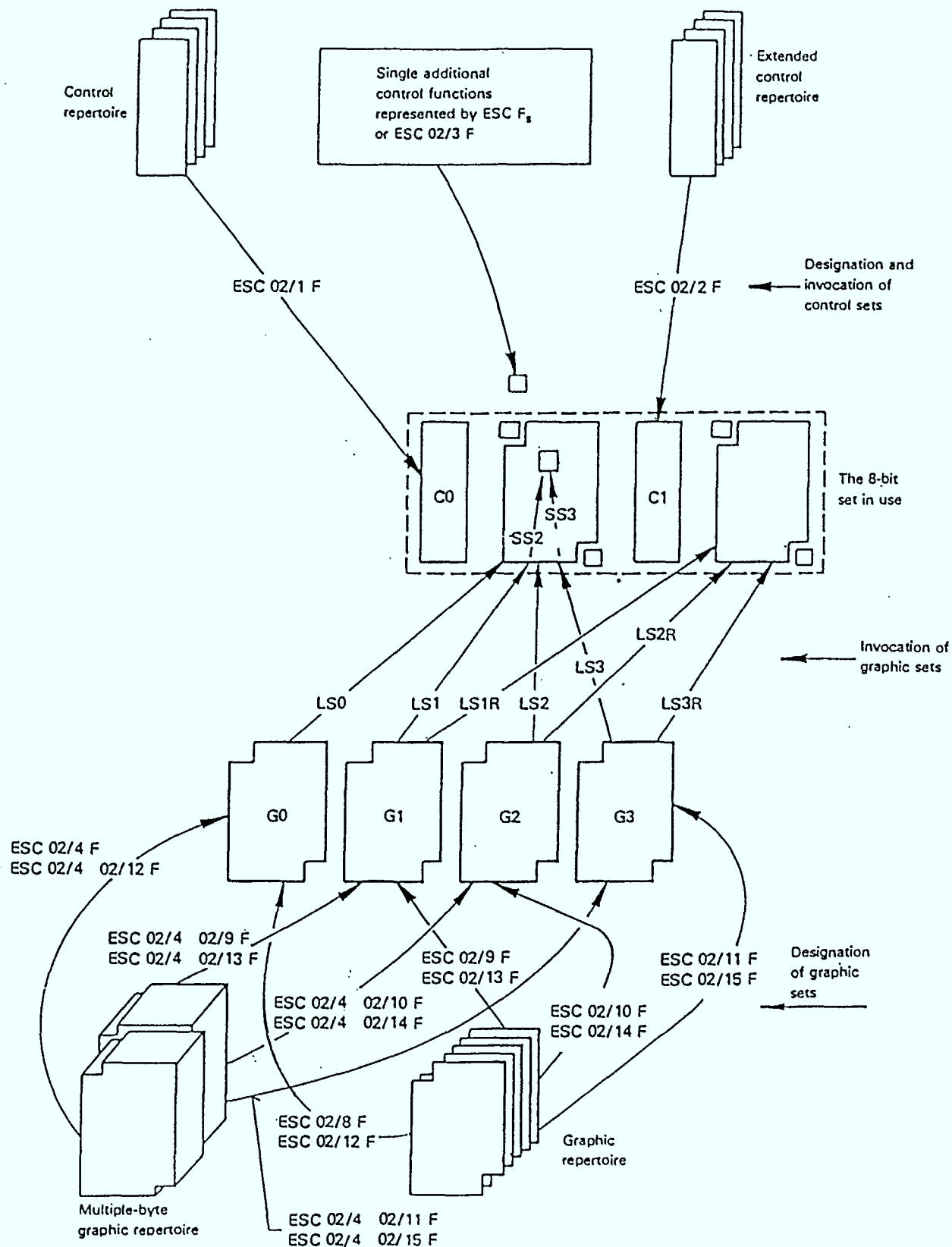


Figure 1-3 Code extension in 7-bit environment (showing all shift functions)

[illegible]

Figure 1-4 8-Bit In-Use Table

The above discussion concentrated on a 7-bit environment. The addition of an eighth bit increases the code table from 128 positions to 256 positions. The code extension techniques are extended to the 8-bit environment in a manner that makes the 7-bit extension scheme a subset of the 8-bit scheme. The 256 position table is divided into 4 regions (Figure 1-4).

Col 0- 1	A control set labelled C0
Col 2- 7	A G table labelled GL
Col 8- 9	A control set labelled C1
Col 10-15	A G table labelled GR

The character codes may still be regarded as 7-bit codes; however, the bit eight becomes a switch specifying the GL or GR set. The full 8-bit scheme is detailed in Figure 1-5.

An 8-bit environment has certain advantages at the receiving terminal. Since two G sets may be in use simultaneously the number of shifting transitions is reduced.

1.2 TRANSFORMATION ALGORITHM

The problem of transforming between 7-bit and 8-bit environments is primarily a problem of handling the shift functions correctly. The only transformation on the character code is simply setting or clearing bit 8, since the character tables have 7-bit addresses and bit 8 is only used to invoke the character table into the left table, GL, or the right table, GR. This poses the algorithm with the problem of deciding when going to the 8-bit environment of whether to map a G set into GL or GR. Another problem is specifying the transformation so that the inverse transformation will switch data back from a 7-bit environment into the correct side of the 8-bit tables. This is termed preserving 8-bit positional information in the transform.

The algorithm presented below is designed to act on a stream of coded data. It cannot determine, however, if the data is 7-bit or 8-bit. The environment setting must be supplied as an input parameter together with the data stream. The single output will be the data stream transformed into the other environment.

The ISO 2022 standard allows the facility of declaring various subsets of the full code extension. This is achieved by defining a set of Announcer codes. An Announcer code is a character sequence of the form:

1/11 2/0 F

where F is a character from column 4 or 5. The full list of Announcer codes is defined in Figure 1-6. Each announcer code specifies the appropriate transformation for the shift function, and the position location in the 8-bit environment.

The set of shift functions described in Figure 1-6 may be termed the set of **legitimate** shift functions specified under ISO 2022. A legitimate shift function is not recognized by the algorithm until it is presented explicitly in an Announcer code or implicitly in the default set assumed by the algorithm on initialization. Such shift functions will be termed **valid** shift functions. Valid shift functions are indicated by setting the valid flag in the Announcer code entry in Table 1-1.

An examination of Table 1-1 reveals some possible conflicts in the data presented. For instance, if Announcer codes 5/2 and 5/3 are entered does the GL table get transformed into GL or GR?

As part of the validation process, the algorithm will screen the set of shift functions presented to it, to detect any inconsistencies. Inconsistent data will be rejected. The following combinations are judged inconsistent:

4/1, 4/2, 4/3, or 4/4 in combination with any other announcer excluding
 announcers 4/6, 4/7, 5/10 or 5/11,
 4/6 and 4/7 in combination,
 5/2 and 5/3 in combination,
 5/4 and 5/5 in combination,
 5/6 and 5/7 in combination.

7-Bit to 8-Bit Telidon Conversion

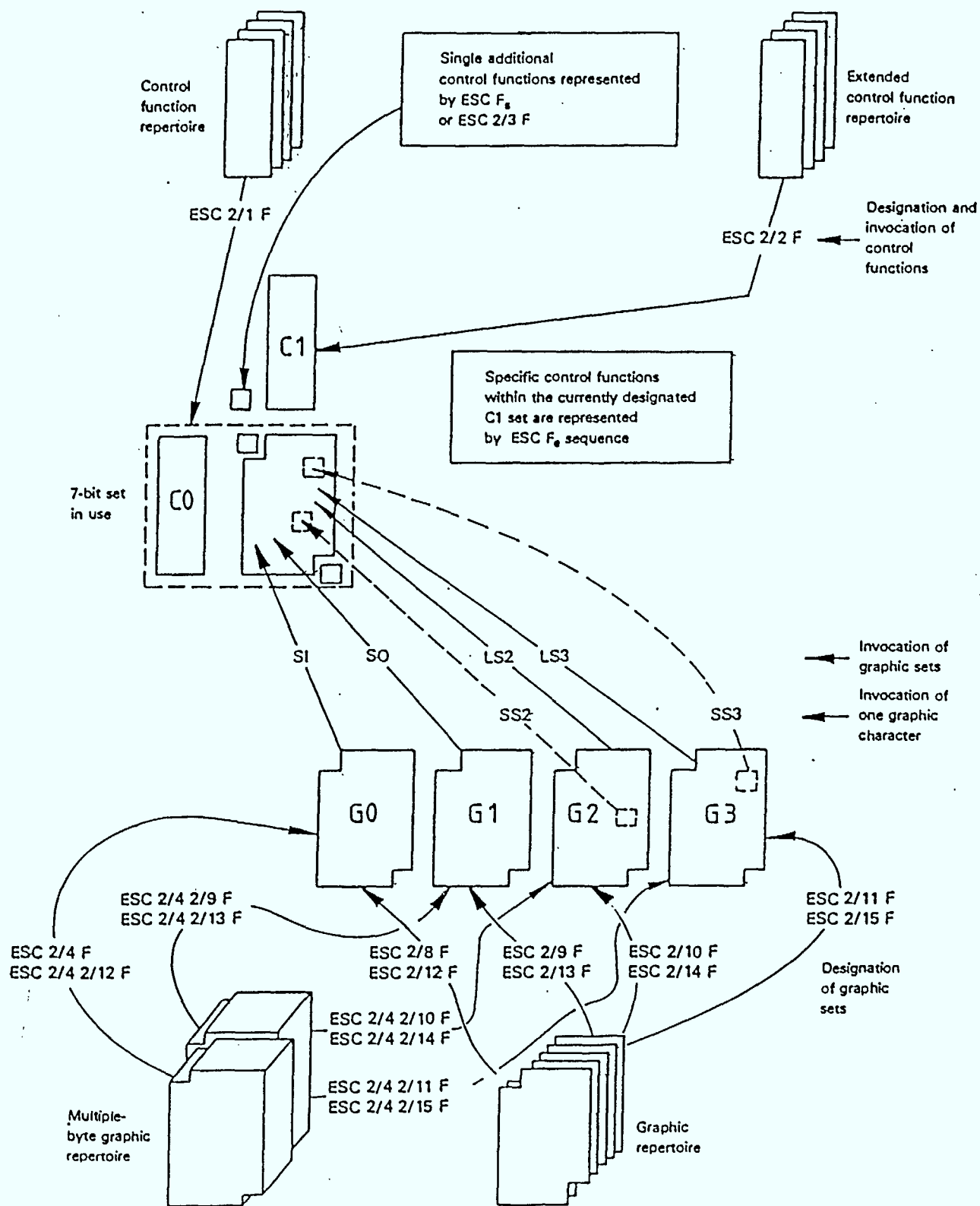


Figure 1-5 Code extension in 8-bit environment (showing all shift functions)

Final character	Facilities utilized	7-bit environment	8-bit environment
4/1	The G0 set shall be used. The escape sequence which designates this set also invokes it into columns 2 to 7. No locking-shift functions shall be used. In an 8-bit environment, columns 10 to 15 are not used.		
4/2	The G0 and G1 sets shall be used. In a 7-bit environment SI invokes G0 into columns 2 to 7 and SO invokes G1 into columns 2 to 7. In an 8-bit environment, LS0 invokes G0 and LS1 invokes G1 into columns 02 to 07, while columns 10 to 15 are not used.		
4/3	The G0 and G1 sets shall be used in an 8-bit environment only. The designating escape sequences also invoke the G0 and G1 sets into columns 02 to 07 and 10 to 15, respectively. No locking-shift functions shall be used.		
4/4	The G0 and G1 sets shall be used. In a 7-bit environment, SI invokes G0 and SO invokes G1 into columns 2 to 7. In an 8-bit environment, the designating escape sequences also invoke the G0 and G1 sets into columns 02 to 07 and 10 to 15 respectively; no locking-shift functions shall be used.		
4/5	Full preservation of shift functions is maintained when transforming data between 7-bit and 8-bit environments.		
4/6	The C1 set shall be used. In both a 7-bit and an 8-bit environment, each C1 control function shall be represented by an ESC F _e sequence.		
4/7	The C1 set shall be used. In a 7-bit environment, each C1 control function is represented by an ESC F _e sequence. In an 8-bit environment, each C1 control function is represented by a single bit combination from columns 08 and 09.		

Figure 1-6 Announcement of extension facilities

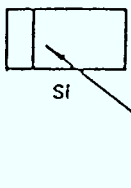
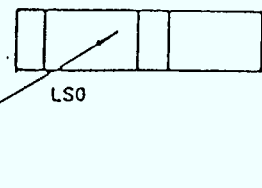
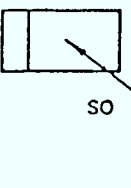
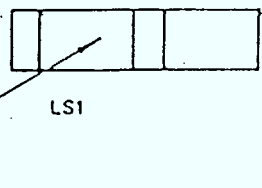
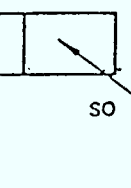
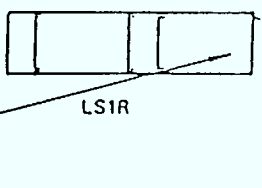
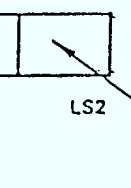
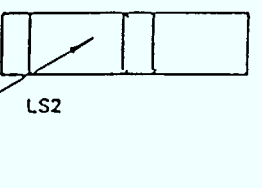
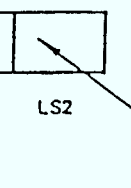
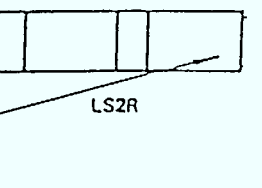
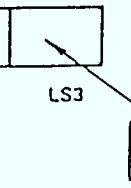
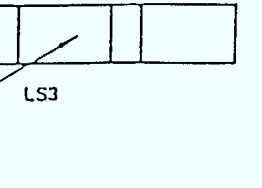
Final character	Facilities utilized	7-bit environment	8-bit environment
5/0	In addition to any other category of graphic sets which may be used, the G0 set shall be used. It will be invoked by SI in a 7-bit environment and by LS0 in an 8-bit environment.		
5/2	In addition to any other category of graphic sets which may be used, the G1 set shall be used. It will be invoked by SO in a 7-bit environment and by LS1 in an 8-bit environment.		
5/3	In addition to any other category of graphic sets which may be used, the G1 set shall be used. It will be invoked by SO in a 7-bit environment and by LS1R in an 8-bit environment.		
5/4	In addition to any other category of graphic sets which may be used, the G2 set shall be used. It will be invoked by LS2 in both 7-bit and 8-bit environments.		
5/5	In addition to any other category of graphic sets which may be used, the G2 set shall be used. It will be invoked by LS2 in a 7-bit environment and by LS2R in an 8-bit environment.		
5/6	In addition to any other category of graphic sets which may be used, the G3 set shall be used. It will be invoked by LS3 in both 7-bit and 8-bit environments.		

Figure 1-6 Announcement of extension facilities (continued)

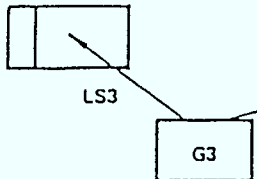
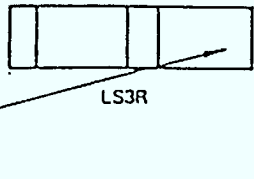
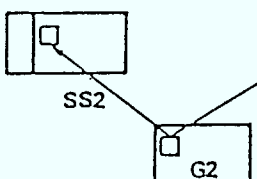
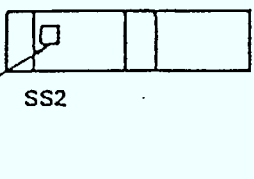
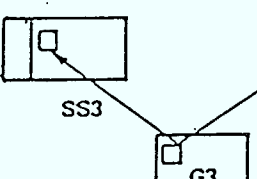
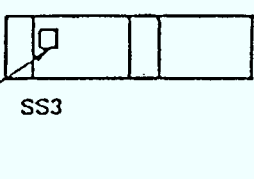
Final character	Facilities utilized	7-bit environment	8-bit environment
5/7	In addition to any other category of graphic sets which may be used, the G3 set shall be used. It shall be invoked by LS3 in a 7-bit environment and by LS3R in an 8-bit environment.		
5/10	In addition to any other category of graphic sets which may be used, the G2 set shall be used. SS2 shall invoke a single character of this set in both 7-bit and 8-bit environments.		
5/11	In addition to any other category of graphic sets which may be used, the G3 set shall be used. SS3 shall invoke a single character of this set in both 7-bit and 8-bit environments.		

Figure 1-6 Announcement of extension facilities (continued).

Example 1: Announcer codes 5/2, 5/3
 7-bit 8-bit
 S0 Col 3 -> LS1 Col 3

where Col 3 denotes a character in column 3.

Example 2: Announcer codes 5/2, 5/3
 8-bit 7-bit
 LS1R Col 10 -> S0 Col 3
 LS1 Col 3 <- S0 Col 3

Example 3: Announcer codes 4/5, 5/2, 5/3
 Eight bit 7-bit
 LS1R Col 10 -> LS1R Col 3
 LS1R Col 10 <- LS1R Col 3

i.e. Positional information is preserved.

The appearances of the shift function LS1R, LS2R, LS3R in a 7-bit environment require some explanation. They are introduced by the scheme for preserving 8-bit positional information. However the following interpretation is applied. In a 7-bit environment LS1R, LS2R, LS3R will be interpreted as LS1, LS2, and LS3 respectively. The Announcer code 4/3 is excluded from the set of Announcer codes listed in Table 1-1 since, by definition, it precludes the validity of transforming into a 7-bit environment.

The two Announcer codes 4/6, 4/7 specify how the C1 control set is to be invoked in an eight bit environment. A flag CFLAG is maintained by the algorithm with the following meaning:

CFLAG = 0 C1 invoked in columns 8, 9 (Announcer 4/7)
 1 C1 invoked by 1/11 F where F is an entry in column 4 or 5
 (Announcer 4/6)

1.3 'COMPLETE CODE' PROCESSING

A complete code statement is an escape sequence of the form:

ESC 2/5 F

Where the final character F from column 4 to 7 must be registered with ISO. A complete code describes the full coding environment, both control codes and graphic characters. The algorithm will regard a complete code statement as a set of implicit Announcer codes. For instance, the Telidon complete code statement

ESC 2/5 F1

is equivalent to the following set of Announcer codes:

ESC 2/0 4/7
 5/0
 5/3
 5/5
 5/7
 5/10
 5/11
 4/5

The scheme so far described suffers from one drawback that may require rectification. Announcer codes may be added to the Announcer table by including them in the input data stream. However, no provision exists for removal of an Announcer entry. For instance, in the Telidon environment the preservation of 8-bit positional information when transforming to 7-bit may not be required. This would involve removing the Announcer entry 4/5 from the Announcer Table, for the algorithm to function correctly.

One solution to this problem would be to define a special Announcer code that would signal the user's intention of entering a new set of Announcer codes. The effect of this code would be to clear all valid flags in the Announcer table. The set of Announcer codes to follow would set up a new Announcer table configuration. This scheme has an awkward feature. In order to turn off one Announcer code (eg 4/5) the user would have to re-enter all the other valid Announcer codes again.

Since this proposed scheme is not part of the existing standard, it would have to be submitted to the ISO for possible inclusion in future versions of the standard. The actual escape sequence might be one of the unused Announcer codes e.g.

ESC 2/0 5/15

or an entry from the reserved set

ESC 2/7 F

1.4 ALGORITHM FLOW CHARTS

The flow charts are presented in Figures 1-8 and 1-9. Figure 1-7 explains the flow chart symbols used. The location Flag (RFLAG) and the transformed shift function in Figure 1-8 are obtained by scanning through the Announcer entries in Table 1-1, until the input shift function is matched by the corresponding entry in the 7-bit shift function column.

In Figure 1-9, the following definitions apply:

LSHIFT: Transformed shift function when eight bit code in GL is transferred to 7-bit.

RSHIFT: Transformed shift function when eight bit code in GR is transferred to 7-bit.

Default settings of these variables are required at initialization. The following defaults apply:

LSHIFT: SI (GO resident in GL)
RSHIFT: S0 (G1 resident in GR)

or LSlR if Announcer code 4/5 specified.

The location flag and transformed shift function are obtained by look up entry in Table 1-1.

The flow charts, as presented, generally agree with the particular examples in Reference 23 and the memo from Mr. G. Watson (Reference 31).

Some typographical errors in Figures 1-16 and 1-17 have been corrected in Reference 31. The following additional corrections have been added:

Reference 1, Figure 16.

- 1 No Announcer code is declared to specify how the C1 control set is to be transformed. The flowchart assumes Announcer code 4/7. This should be explicitly mentioned in the description.

Reference 1, Figure 17.

- 1 The 8-bit data is declared to have Announcer code 4/3 or 4/4. 4/3 however precludes the possibility of transforming to a 7-bit environment.
- 2 As in Figure 1-16, no Announcer code is provided for the C1 control set transformation.

The example presented in Figures 1-16 and 1-17 seems to allow the facility of declaring one set of Announcer codes to hold in the 7-bit environment, and a different set to hold in the transformed environment. The present algorithm does not accept such a possibility. It regards an Announcer code as the definition of a transformation from one environment to the other.

The present flowcharts are a more complete statement of the examples presented in Figures 1-18, 1-19, 1-20 and 1-21 of Reference 23. The main difference is that the problem of initial values and default setting is fully treated.

7-Bit to 8-Bit Telidon Conversion

Announcer Code	Valid Flag	7-bit Shift	8 Bit Shift	8 Bit Location LFLAG
4/1				GL
4/2		S1 S0	LS0 LS1	GL GL
4/4		S1 S0		GL GR
4/5		LS1R LS2R LS3R	LS1R LS2R LS3R	GR GR GR
5/0		S1	LS0	GL
5/2		S0	LS1	GL
5/3		S0	LS1R	GR
5/4		LS2	LS2	GL
5/5		LS2	LS2R	GR
5/6		LS3	LS3	GL
5/7		LS3	LS3R	GR
5/10		SS2	SS2	GL
5/11		SS3	SS3	GL

Table 1-1 Shift Function Transformations

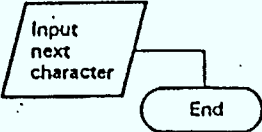
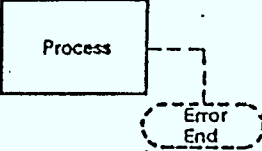

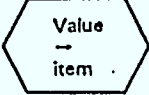

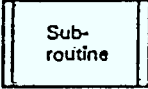
Symbol	Name	Meaning
	Input	To fetch the next character from the input character string and go to the end if there is no further character available.
	Process	To execute the defined process. There may be an error end because of lack of more characters.
	Decision	To examine the item as having the specified value.
	Preparation	To set the item to the specified value.
	Output	To take the last character (output character) or the specified character(s) (output 1/11, 4/14) or the manipulated character (output b ₈ = dropped) to the output character string.
	Predefined process	To execute the appropriate predefined process.

Figure 1-7 Meaning of the flowchart symbols

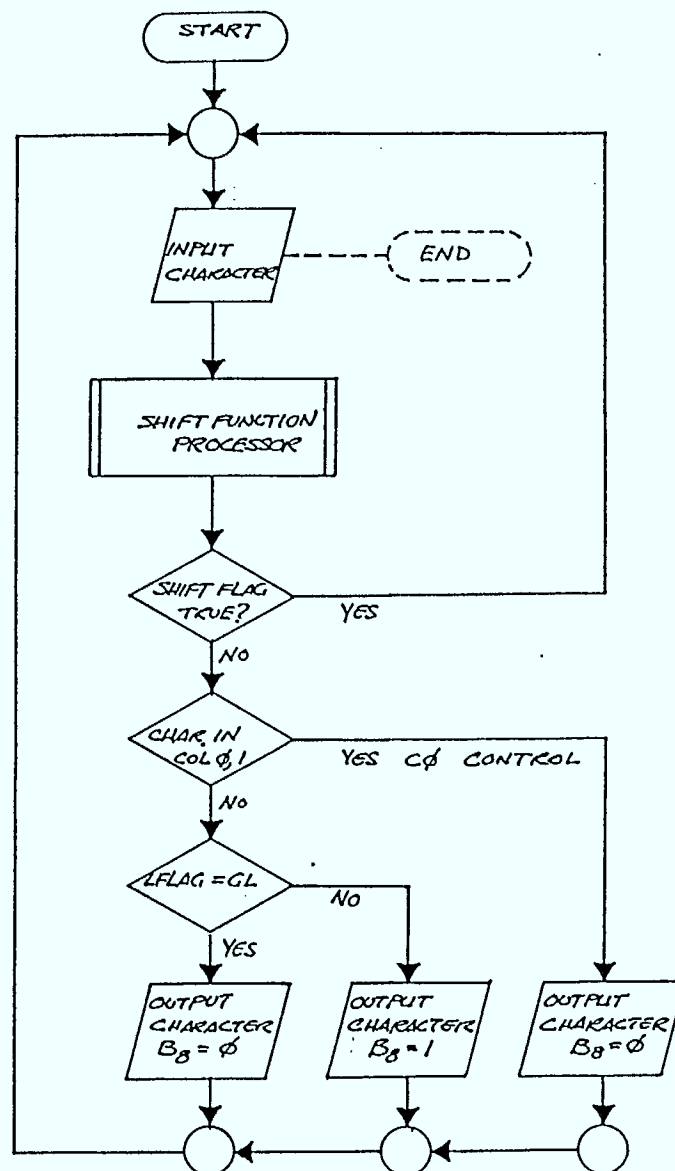


Figure 1-8A 7-Bit to 8-Bit transformation

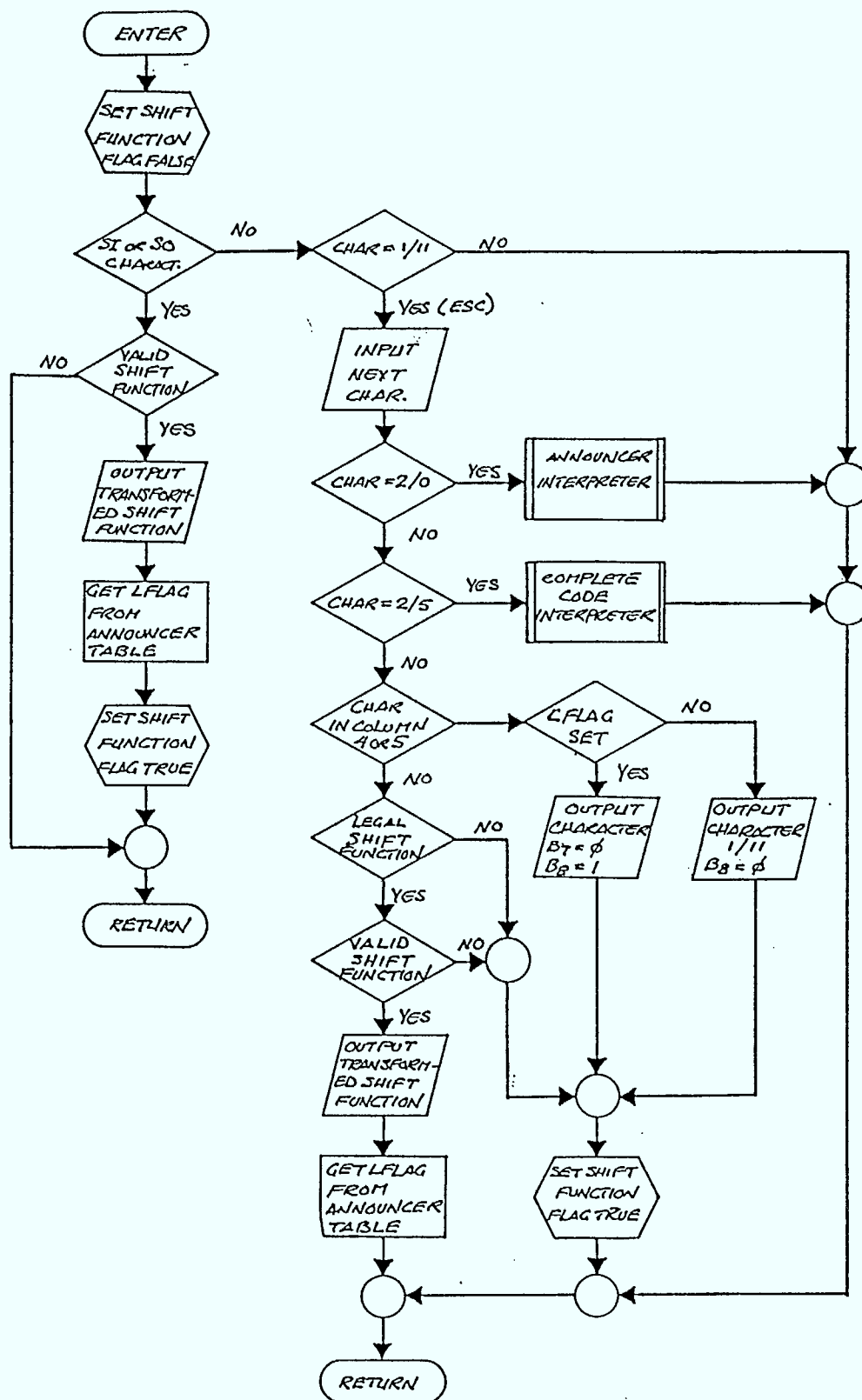


Figure 1-8B 7-Bit to 8-Bit shift function processor

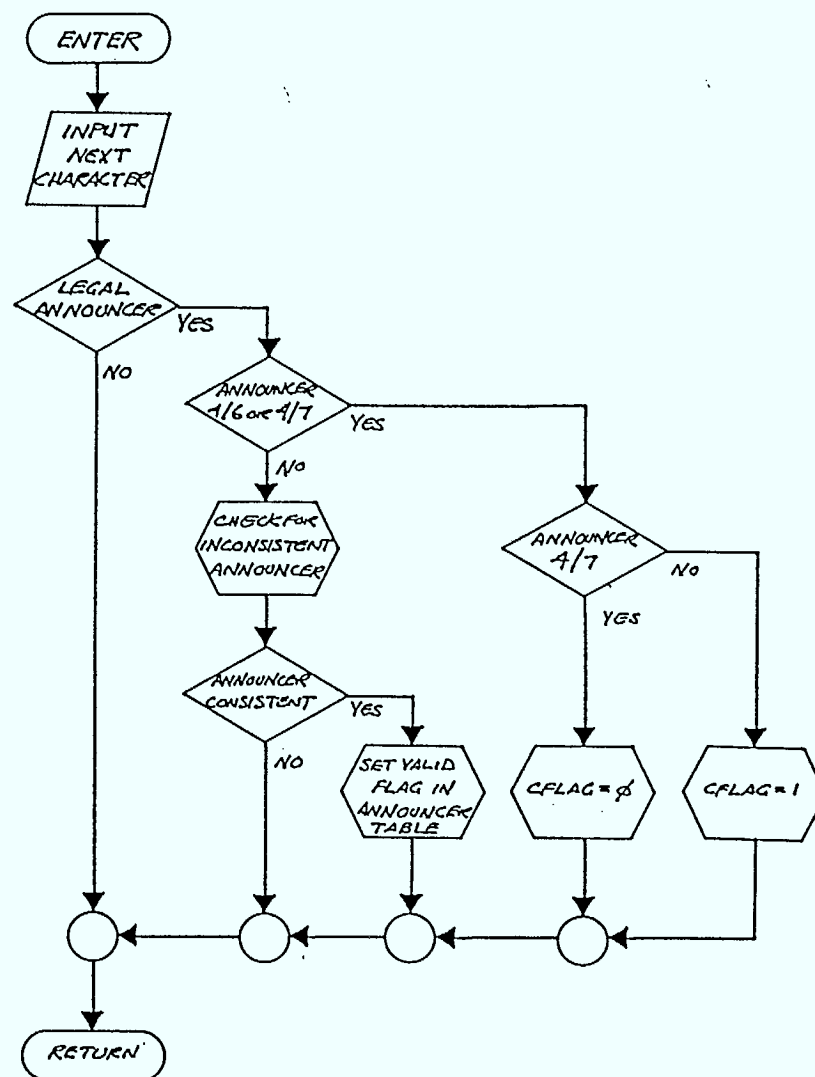


Figure 1-8C Announcer Interpreter 7-Bit <-> 8-Bit

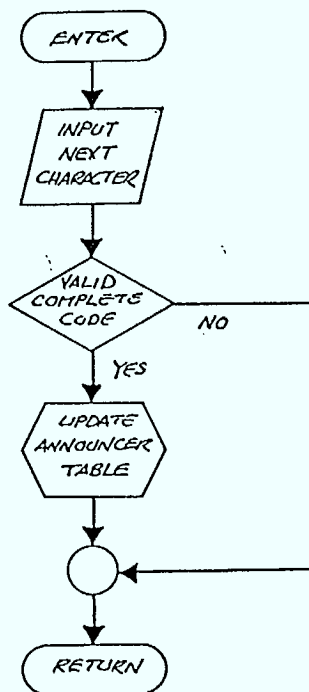


Figure 1-8D Complete Interpreter 7-Bit <-> 8-Bit

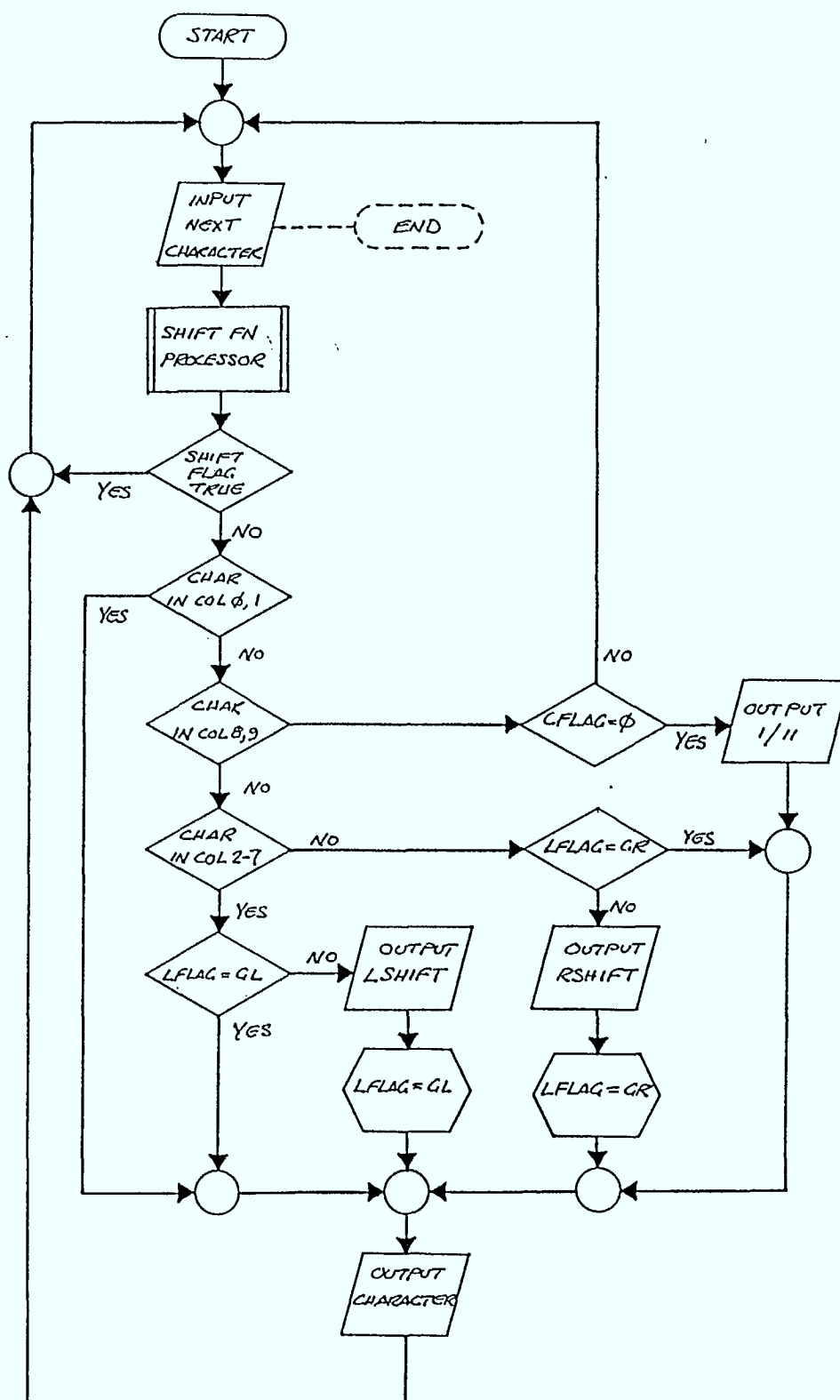


Figure 1-9A 8-Bit to 7-Bit Transformation

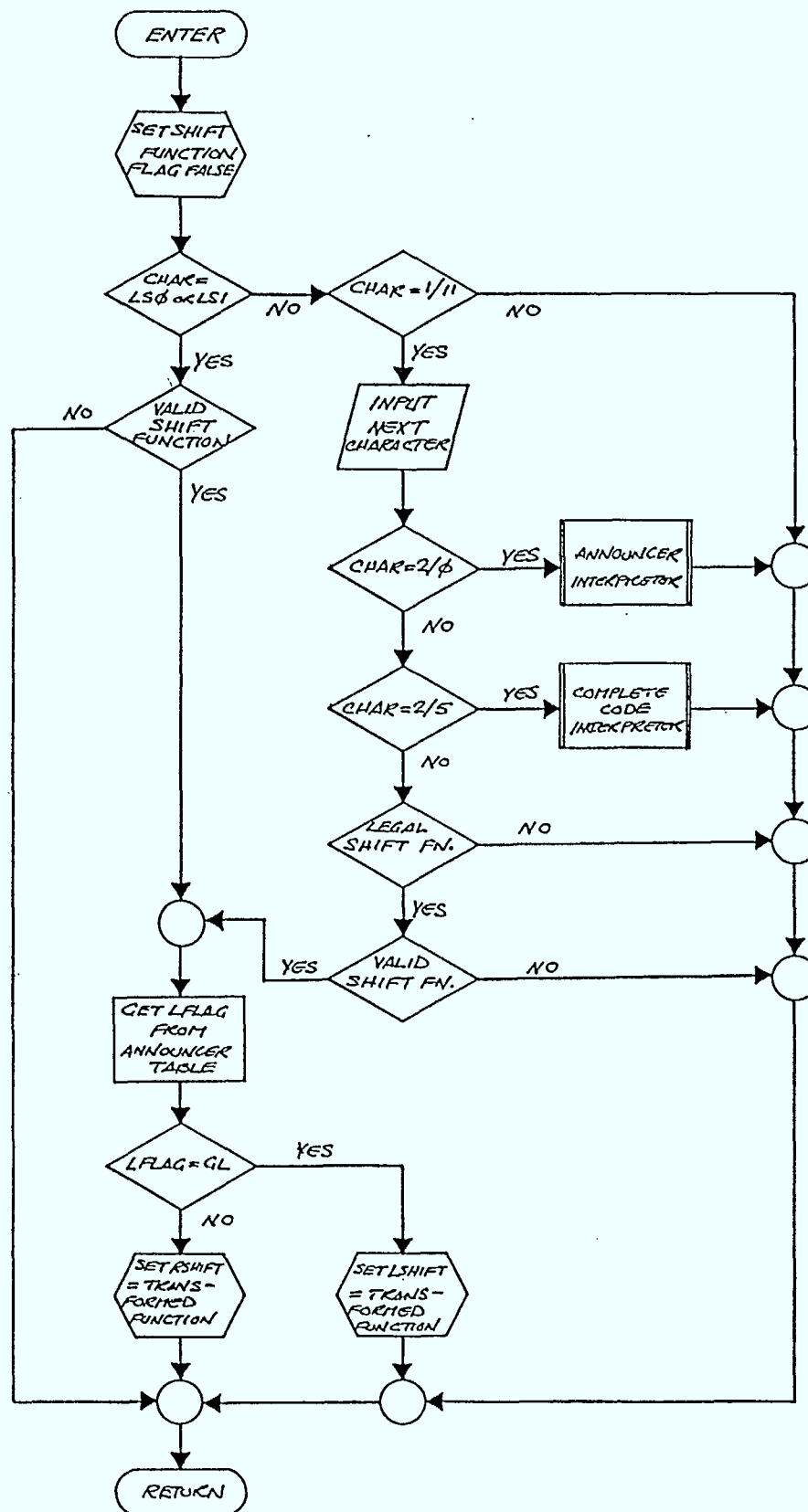


Figure 1-9B Shift function interpreter 8-Bit to 7-Bit

2.0

TRANSFORMATION BETWEEN TELIDON AND TELETEX SYSTEMS

The Teletex service allows subscribers to communicate character coded text material with any other subscriber in the system. The Teletex service is essentially an expansion and upgrading of the familiar Telex service. The emphasis in a Teletex network is on the transfer of information on an automatic memory to memory basis. A Teletex terminal requires a memory facility to allow the automatic receipt and storage of incoming messages even while the terminal is being used in local mode for outgoing message preparation. The Telex graphic character set is restricted to the International Telegraph Alphabet No.2, whereas Teletex has an expanded character set similar to the set used in Telidon. Telex terminals display incoming messages on a hard copy printer. Outgoing messages must be keyed in directly. Teletex terminals, on the other hand, combine many of the features of word processing units with the ability to transmit and receive from other subscribers in the system. In the local mode, documents can be prepared in a manner similar to a conventional word processor. While in the local mode, incoming messages are saved in local store for later viewing. Although a Teletex terminal need not have a hard copy output facility, conventional usage is to regard hardcopy as the normal output. The Teletex standard described in Reference 30 addresses itself largely to the question of outputting on a paper medium. The basic display unit is a page which corresponds to standard paper sizes. Line spacing and character spacing are adjustable. A standard page size can have a maximum of approximately 4000 characters.

The common features of the Teletex service and the Telidon service make the possibility of inter-communication attractive. Both services allow a user the facility to exchange data to a remote site. The character coding schemes used are both derived from the same standard. Differences exist in the communication protocols and the display capabilities of both media. Telidon allows full graphic displays whereas Teletex is restricted to alphanumeric characters. The size of the Teletex page is much greater than the resolution currently normal with Telidon terminals.

This section of the report is only concerned with the problem of mapping a display from one medium to the other. Problems introduced by the different communication protocols are not addressed here. For example, if a Telidon terminal was adapted to receive Teletex messages, it would have to have some facility for storing these messages. Storage could be provided locally in the terminal or in the Videotex Host computer's database. Application software could be developed similar to the currently available messaging software to allow subscribers a Teletex messages to be filed in the Host.

2.1 TRANSFORMING FROM TELETEX TO TELIDON

Teletex encodes character data using an 8-bit coding scheme. The coding scheme follows the standard specified in ISO Standard 2022 (Reference 23). Facilities to extend beyond a 256 code character set exist but are not currently defined. A subset of the Telidon primary character set is designated and invoked into GL. A subset of the Telidon Supplementary character set is designated and invoked into GR (Figures 2-1 & 2-2). The Teletex code table is illustrated in Figure 2-3. Teletex control characters lie within the C0 and C1 sections of the table.

Since the Teletex character set is a subset of the Telidon character set, the transformation presents little difficulty. The only requirement is to invoke the corresponding Telidon G set by issuing an appropriate escape sequence. In Telidon, the default designations are the Primary character set in G0 and the Supplementary set in G2. In a Telidon 7-bit environment G0 and G2 will both be invoked into the single 128 position code table. In a Telidon 8-bit environment G0 can only be invoked into GL. The default invocation for G2 is into GR, but this can be modified by an announcer code.

Teletex control functions are handled differently, since a direct equivalence to all the Teletex control functions does not exist in Telidon. The transformation for each control function is presented in Section 2.3.

2.2 FORMATTING A TELETEX DISPLAY

A Teletex data stream consists of a series of characters organized into units called pages. The start of a page is identified by the control character Form Field (FF, 0/12). Each page consists of a number of lines. A line is terminated by the control characters Carriage Return (CR, 0/13) Line Feed (LF, 0/10). The maximum page size possible is given in Table 2-1.

The maximum number of characters in a Teletex page can be as high as 4312. Conventional Telidon terminals have a resolution of 256x200 pixels, which translates into 40x20 characters, using the standard size character set. This implies that the original format of the document cannot be presented on a Telidon Terminal.

The approach adopted here is to scroll a Teletex page onto a Telidon screen until a Form Feed control character is encountered. The Form Feed will then cause the screen to be cleared and the cursor positioned at the upper left hand corner of the screen, thereby initiating the scrolling of the next Teletex page. The only operation on the Teletex data is to start off the CR-LF combinations. Formatting on the screen is handled by the Telidon scroll on command (C1 set). Once the right edge of the screen is reached, an implicit CR-LF is generated and the display continues on the next line. When the bottom line has been written, each line moves up one position, causing the top line to disappear and leaving the bottom line available for the next string of characters. Telidon also contains a word wrap feature (C1) that may be employed to improve the display.

	10	11	12	13	14	15
EQ UNK 101	2	3	4	5	6	7
0	SPACE	0	@	P		p
1	!	1	A	Q	a	q
2	"	2	B	R	b	r
3	#	3	C	S	c	s
4	\$	4	D	T	d	t
5	%	5	E	U	e	u
6	&	6	F	V	f	v
7	'	7	G	W	g	w
8	(	8	H	X	h	x
9	)	9	I	Y	i	y
10	*	:	J	Z	j	z
11	+	;	K	[	k	{
12	,	<	L		l	|
13	-	=	M	]	m	}
14	.	>	N	^	n	_
15	/	?	O	—	o	■

Figure 2-1 Telidon Primary Character Set.

Shaded entries are not part of the Teletex Character Set

	10	11	12	13	14	15
CO- LUMN ROW	2	3	4	5	6	7
0	SPACE	°	→	←	Ω	K
1	¡	±	~	1	Æ	æ
2	¢	2	'	®	Ð	ð
3	£	3	^	©	ä	ø
4	\$	x	~	TM	Ŧ	ħ
5	¥	μ	—	♪	⌘	ℓ
6	#	¶	˘		IJ	ij
7	§	•	•		Ł	ł
8	✕	÷	¨		ℵ	ℵ
9	€	€	€		Ø	ø
10	€	€	°		Œ	œ
11	<<	>>	ˆ		◊	β
12	←	1/4		1/8	Ɔ	p
13	↑	1/2	"	3/8	Ɔ	ł
14	→	3/4	L	5/8	ħ	h
15	↓	đ	v	7/8	ʎn	■

Figure 2-2 Telidon Supplementary Character Set.

Note: Column 4 (12) is non spacing

Shaded entries are not part of the Teletext Character Set

Transformation Between Telidon and Teletex Systems

				b.	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	
				b.	0	0	0	0	1	1	1	1	0	0	1	1	1	1	1	
				b.	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	
				b.	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	
					0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
b.	b.	b.	b.																	
0	0	0	0	0			SP	0	à	P		p				o			Ω	κ
0	0	0	1	1			!	1	A	Q	a	q			i	±	`		Æ	œ
0	0	1	0	2			"	2	B	R	b	r			e	2	'		ð	đ
0	0	1	1	3				3	C	S	c	s			£	3	^		ä	ð
0	1	0	0	4				4	D	T	d	t			\$	x	~		H	h
0	1	0	1	5			%	5	E	U	e	u			¥	μ	-			ı
0	1	1	0	6			&	6	F	V	f	v			#	¶	~		IJ	ij
0	1	1	1	7			'	7	G	W	g	w			§	.	.		Ł	ł
1	0	0	0	8	BS		(	8	H	X	h	x			¤	÷	..		Ł	ł
1	0	0	1	9			)	9	I	Y	i	y					ø		Ø	ø
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z					°		Œ	œ
1	0	1	1	11		ESC	+	;	K	[	k		PLD	CSI	<<	>>	,		°	β
1	1	0	0	12	FF		,	<	L		l	ı	PLU			¼	⊖		þ	p
1	1	0	1	13	CR		-	=	M	]	m					½	"		Ŧ	ŧ
1	1	1	0	14			.	>	N		n					¾	˘		ŋ	ŋ
1	1	1	1	15			/	?	O	⊖	o					ı	˘		n	

CCITT-40400

Figure 2-3 Teletext Character Set

Note 1: When interworking with Videotex, this code shall have the meaning delimiter

Note 2: When a distinction needs to be made between diaeresis and umlaut mark, this code shall be used to represent umlaut mark

Note 3: Non spacing underline is not a diacritical mark and may be combined with any graphic character of the Teletex repertoire

Column 12 is non-spacing

BASIC PRINTABLE AREAS

Paper Orientation		Vertical	Horizontal
Maximum number of lines per page	Line spacing (mm)		
	1	56	39
	1.5	37	26
	2.0	28	19
Maximum number of characters per line	Character spacing (mm)		
	2.54	77	105

Table 2-1

2.3

TELETEX CONTROL FUNCTIONS

Teletex control functions are divided into two sets: The first set is represented by the code elements from the C0 and C1 regions (Figure 2-3) Control functions with defined parameters have the representation

$$\text{CSI } P_1 \dots P_n \ I_1 \dots I_m \ F$$

where CSI is the Control Sequence Introducer 9/11

P_i Parameters from Column 3 (3/0 → 3/15)

I_i Identification from column 2 (2/0 → 2/15)

F Final byte from column 4-7

Some Teletex control functions map directly into equivalent Telidon control functions; others require interpretation. Each function is discussed separately below.

BACKSPACE (BS)

Code representation is 0/8. This translates into Telidon C0 control code 0/8.

LINE FEED (LF)

Code representation is 0/10. This control code will not be passed to the Telidon terminal.

FORM FEED (FF)

Code representation is 0/12. This signal the end of a Teletex page. It advances the cursor from the present position to the corresponding position at the start of a new page. It will generally be followed by a Carriage Return to return the cursor to the Home position. It will be transformed to the Telidon C0 control code 0/12 (clear screen). This clears the screen and positions the cursor at the top left of the screen.

CARRIAGE RETURN (CR)

Code representation is 0/13. This control code will not be passed to the Telidon terminal.

SUBSTITUTE CHARACTER (SUB)

Code representation is 1/10. This control code is used to print an error indication or otherwise identify the location of a character received in error. It will be transformed into 7/15 ("177"), causing a solid rectangular display.

ESCAPE (ESC)

Code Representation is 1/11. This control code is reserved for code extension since no code extension is defined in the current Teletex standard, it should not appear in the input stream. If it does, it will be discarded to avoid causing problems in the Telidon terminal.

PAGE FORMAT SELECTION (PFS)

Code representation is
CSI P 2/0 4/10

where

P = 0 Vertical page format (default)
= 1 Horizontal page format

Vertical page format corresponds to the standard Telidon display format of writing across the screen and then down. A horizontal page format corresponds to writing down the page first and then across. Both options are controlled by the character path movement field in the PDI Text character code.

SELECT GRAPHIC RENDITION (SGR)

Code representation is
CSI P 6/13

where

P = 0 default mode
= 4 character underlined

These options are transferred into the PDI C1 functions,
Underline off or Underline on.

SELECT HORIZONTAL SPACING (SHS)

Code representation is
CSI P 2/0 4/11

where

P = 0, 10 characters for 25.4 mm.

The default Telidon spacing is a space width corresponding to the width of the current character set. This default will be used and the SHS control code ignored.

SELECT VERTICAL SPACING (SVS)

Code representation is
CSI P 2/0 4/12

where

P = 0 6 lines per 25.4 mm
= 1 4 lines per 25.4 mm
= 2 3 lines per 25.4 mm
= 3 12 lines per 25.4 mm

Inter row spacing is controlled by the inter row spacing field of the PDI Text Character code. The following transformation will be done:

P = 0 transforming into inter row spacing 1
1 transforming into inter row spacing 1.25
2 transforming into inter row spacing 1.5
3 transforming into inter row spacing 2

PARTIAL LINE DOWN (PLD)

Code representation is
8/11

This control code defines the start of a subscript or the end of a superscript. It moves the cursor down by a vertical offset not exceeding a half line space. The rest of the line will be displayed at the new vertical position unless a PLU control code is received. The terminal may choose to implement this function by employing special fonts (generally reduced size) to avoid overlapping characters.

There is no equivalent control code in Telidon. A subscript or superscript could be implemented by keeping track of the cursor position, and setting up the vertical offset when required. Inter row spacing would have to be increased beyond 1 if no special font were available. Otherwise character overlap would occur. The present simple scheme of scrolling Teletex data would have to be discarded. The high overhead of supporting subscripting or superscripting is not felt to be justifiable. Consequently the algorithm will simply transform PLD into a bracket depending on the context ie.

PLD Start of subscript	-	transform into (
PLD End of subscript	-	transform into)
PLU Start of superscript	-	transform into (
PLU End of superscript	-	transform into)

2.4 TRANSFORMING FROM TELIDON TO TELETEx

Transforming in this direction raises the question of how to represent a high information signal in a lower information medium. A Teletex system can only display alpha numeric data. Any graphic information defined by elements of the PDI set or the DRCS set cannot be represented on a Teletex system. With this major factor missing, the information content of the output signal may be severely degraded. The main design consideration of the algorithm presented below is how to minimize this degradation and convey the maximum amount of information possible.

Telidon alpha-numeric characters will be transformed directly into Teletex characters. If no corresponding character exists, a substitute character will be used provided it does not affect the meaning.

A Telidon screen will be mapped directly into a Teletex page. The graphic content if any, of the Telidon page will, however, be missing. Certain character attributes like size and colour will be lost in the transformation. However, the position of the characters on the Telidon screen will be retained by the transformation. The mapped Teletex page may be considered a snap-shot of the Telidon screen with the following alterations.

1. Graphic images replaced by blank space.
2. Character sizes appearing in default Teletex size.
3. Character colour replaced by white.

The retention of character positional information is considered an important factor in minimizing information loss. Template forms, columns of tabular data etc use the screen layout as an intrinsic part of the their presentation. The algorithm will keep track of the cursor position by analyzing the entire input data stream. PDI data elements are not part of the output data stream, but their effect on the cursor must be determined before they are discarded.

2.5 PROCESSING ALGORITHM

Character information may appear on the screen in any sequence. In order to make the output conformable to a hard copy Teletex terminal, the data will be assembled first in an internal buffer. This buffer will be in a one to one mapping with character position on the screen. It will be sized to correspond to the lowest resolution available on a Telidon terminal. This is currently 20 rows of 80 characters. Each line will be terminated by a Carriage Return, Line Feed combination.

The algorithm will scan through the incoming PDI stream, searching for Text Data. Text characters are preceded by the shift function SI (0/15). Position information will be conveyed either directly through the Operation code SET POINT or indirectly through a movement of the drawing point. The Operation code TEXT specifies the relationship between the drawing point and the text cursor. Four possibilities may be specified.

1. Text cursor and drawing point move together (default)
2. Text cursor leads
3. Drawing point leads
4. Text cursor is independent of the drawing point

Text cursor leads, means that the drawing point follows a movement of the text cursor, but a movement of the drawing point has no effect on the text cursor. A similar explanation holds when the drawing point leads. The drawing point is affected by the following PDI drawing commands.

POINT
LINE
ARC
RECTANGLE
POLYGON

If the TEXT command specifies mode 2 or 4, the algorithm can ignore completely the graphics data. In modes 1 and 3, it must keep track of the drawing point in order to know where the text cursor is.

A default cursor position will be assumed as screen top left. The PDI stream that describes the screen will then be scanned. Any text data encountered will be inserted into the appropriate location in the output buffer. At the end of data, a form feed will be appended and the entire output buffer sent to the Teletex terminal.

This approach poses one serious question. How can the algorithm detect the end of the current screen. The presentation level protocol does not address this problem. Generally a screen will commence with a RESET command that clears the screen and enables the default cursor position. Other possibilities are that the screen may be scrolling text, or writing into a specific area on the screen defined by the FIELD Operation Code.

The recommendation presented here is, that a special end of screen marker be incorporated into the input PDI data stream for this transformation process. The detection of such a marker will complete the processing of the current screens and initiate the output process. One of the currently unassigned 3 character escape sequences could be used for the marker ie:

ESC 2/6 F

or

ESC 2/7 F

where F is an entry from column 3 to column 7.

The implication of this approach is that a standard Telidon database could not be displayed on a Teletex terminal. Incorporation of the end of screen marker would have to be done at page creation time, or later as a separate pre transformation activity. The restrictiveness of this approach is balanced by the limited practicality in transforming Telidon pages to a Teletex display format.

3. TELIDON TO FACSIMILE CONVERSION

This section of the report discusses the development of an algorithm for the conversion of Telidon information into a format suitable for reproduction on Facsimile type devices. Points discussed in the development are the differences in image dimensions between Telidon and Facsimile media, the representation of colour information on a black and white device, and the different resolutions of the two media.

3.1 A BRIEF OVERVIEW OF THE TELIDON AND FACSIMILE MEDIA

Telidon is a CRT terminal based media that uses vector commands called PDI's to produce colour images (Ref.10). The vectors describe images within the bounds of a unit square grid that represents the CRT screen. Within the grid, the smallest point that can be defined is called a "pixel". The number of pixels that may exist along an axis of the unit grid defines the terminal's resolution. For example, if a CRT is capable of imaging 256 pixels along its x or y axis, then the grid resolution is said to be 256x256. Standard CRT monitors, however, have a rectangular, not square, imaging area. The ratio of their horizontal length to vertical height, or aspect ratio, is approximately 4:3. For a 256 pixel resolution monitor, this results in a 256x202 pixel image area (Figure 3-1).

Telidon PDI's have been designed to be as unhampered by hardware restrictions as possible. There is virtually no limit to the resolution to which PDI's may be defined. Current Telidon terminals have a resolution of 256 pixels. When a Telidon terminal receives PDI's, if required, it will truncate the PDI vector coordinates to the resolution that it is capable of imaging.

Facsimile is a service that is used to transmit black and white graphic image data from one centre to another via telephone lines. It is based on paper hardcopy. Source documents are on paper and the produced facsimiles are output on paper.

The word "document" is interpreted to mean the guaranteed reproducible area for the North American standard size facsimile page. As per CCITT Recommendation F.170 for North American standard size documents (Ref 30), documents shall have 10mm margins on all four sides, and a guaranteed useable area of 195mm wide by 260mm high (Figure 3-2). These dimensions correspond to an aspect ratio of 3:4.

The smallest reproducible spot on a Facsimile page is called a Picture Element, or PEL. Facsimile has a horizontal resolution of 8.04 PEL/mm and a vertical resolution of 7.7 PEL/mm or 1567x2002 PEL for 195x260mm area.

PEL's are binary by nature. They may be either "on" or "off", that is black or white. There are no provisions for grey levels within a PEL.

Facsimile represents an image as a series of raster lines. Images are scanned, transmitted and reconstituted on a line-at-a-time basis read from left to right, top to bottom. Prior to transmission of the data over phone lines, data is compressed using a coding scheme known as Huffman codes (Ref 3).

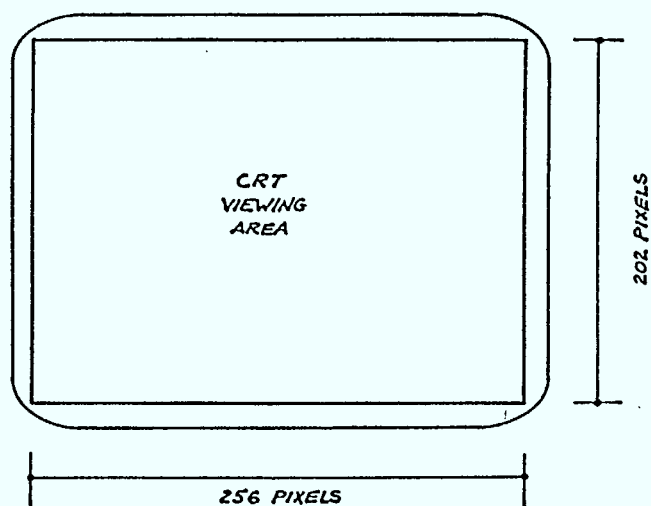


Figure 3-1 Typical Telidon viewing area indicating 4:3 aspect ratio

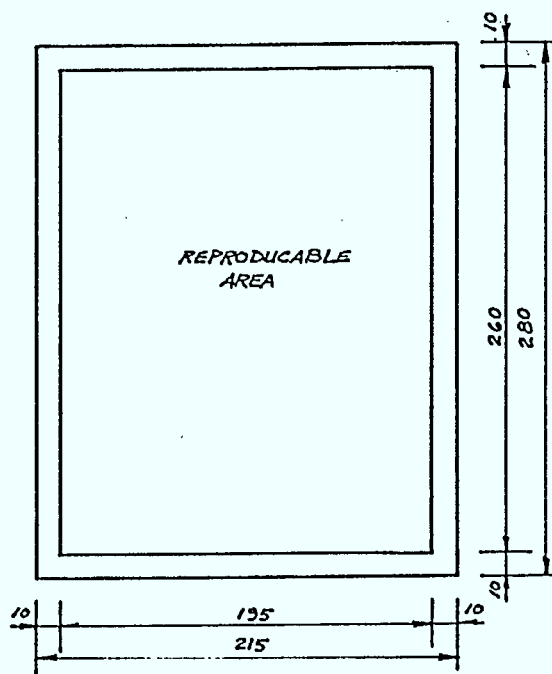


Figure 3-2 Dimensions of reproducible area for North American standard Facsimile document

3.2 FORMAT DIFFERENCES

The purpose of this section is to identify the problem areas associated with converting Telidon information to Facsimile and to propose possible solutions. There are three problem areas: aspect ratio differences, translation from Telidon colour to monochrome Facsimile and vector to raster conversion.

3.2.1 Page Size Differences

The two media have distinctly different aspect ratios. To convert from a Telidon screen to a Facsimile page, some method is needed to reconcile this difference. It is desirable for Telidon-to-Facsimile conversion process to use as much of the image area of the two media as possible. Since Telidon screens have an aspect ratio of 4:3 and standard Facsimile pages have a ratio of 3:4, this implies that the Telidon information will have to be rotated by 90° to have it fit on a Facsimile page.

The structure of a typical PDI vector command is shown in Figure 3-3 (see Ref.10 for complete details). The operand bytes contain the x and y coordinate information that must be rotated by 90° to achieve the effective aspect ratio transformation.

Given that all coordinates fall within the unit area, then a counter clockwise 90° rotation may be described thus:

$$\begin{aligned} Y' &= X \\ X' &= 1 - Y \end{aligned}$$

where X' is the transformed x-coordinate
 Y' is the transformed y-coordinate
 X is the original x-coordinate
 Y is the original y-coordinate

Substituting the X' and Y' values back into the vector command completes the rotation (Figure 3-4). This approach has several advantages: the entire Telidon screen may be mapped into a facsimile page. The PDI vector list is manipulated instead of a screen's raster bit-plane. Thus the operation is not necessarily limited to a particular screen's resolution.

3.2.2 Translation of Telidon Colour to Facsimile Black & White

Telidon is by design a colour oriented media, while Facsimile is monochromatic. Transmitting Telidon images to a Facsimile receiver implies representing colour information on a black and white device. To achieve this, a method for mapping colour into grey levels must be devised along with a method for representing grey tones on a binary black and white media.

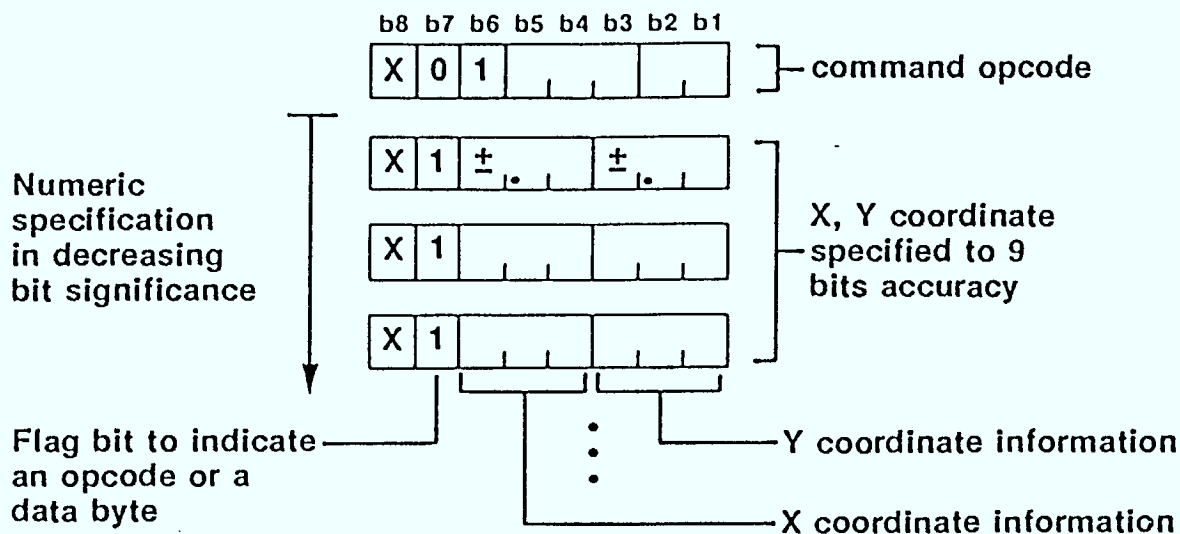


Figure 3-3 Telidon PDI that uses vector co-ordinates

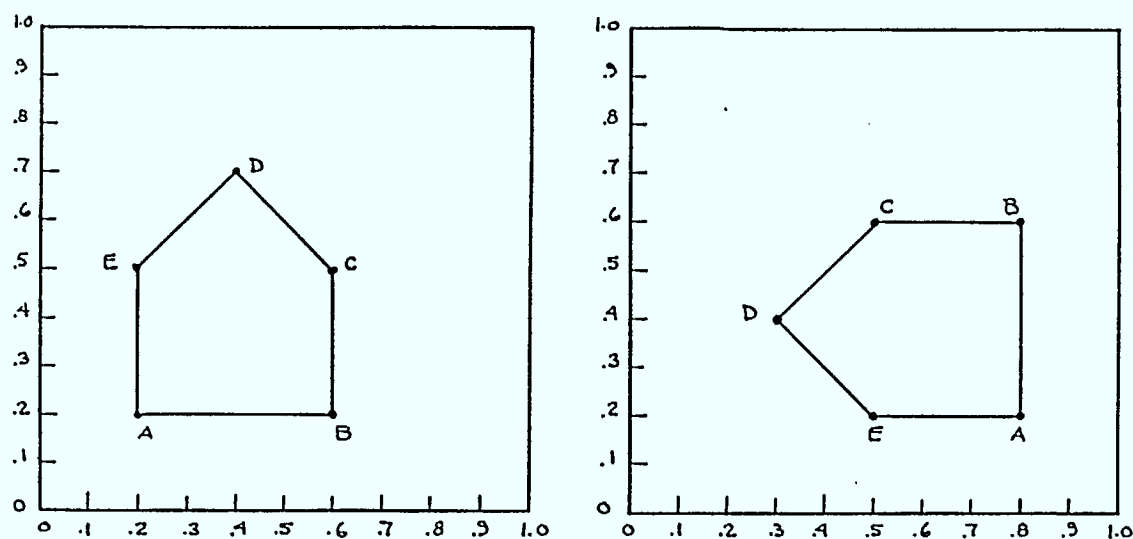


Figure 3-4 Example of a 90° co-ordinate rotation

The conversion of colour images to their grey level equivalents has long been practiced in the television industry. As the theory of this type of transform is well documented (Ref.29) it will not be treated in depth at this point. Suffice it to say that there exists a linear combination of red, green and blue components that will produce a colour that is perceived as white. This combination is called the luminance of the signal and is expressed as:

$$L = 0.30 R + 0.59 G + 0.11 B$$

where L is the luminance or brightness

R is the red intensity, range 0 to 1

G is the green intensity, range 0 to 1

B is the blue intensity, range 0 to 1

When the values of R, G and B are unity, the brightness is a maximum of one. As the R, G, B intensities vary, all combination of brightnesses are possible. When a monochrome device, such as a monitor, receives a colour signal, this method is used to convert the signal into a monochrome image.

It is suggested that this same method be applied to convert colour PDI's to grey levels. Figure 3-5 is the Telidon PDI for SET COLOUR, the command used to select the drawing colour. The conversion involves separating the R, G, B bytes and substituting them into the luminance equation. The resultant brightness level is used in simulation of Facsimile grey levels.

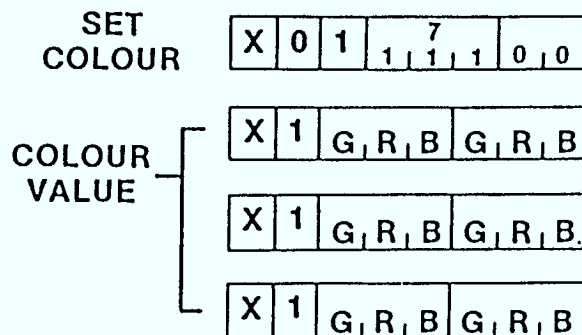


Figure 3-5 PDI SET COLOUR Command

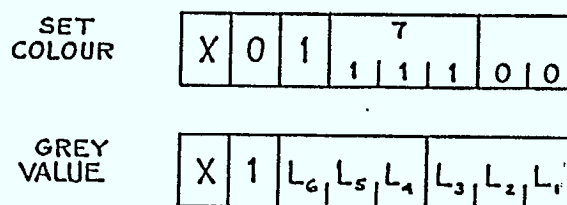


Figure 3-6 PDI SET COLOUR command modified to specify grey level

3.2.3 Telidon Grey Level to Facsimile Grey Level Conversion

The Facsimile PEL is not capable of multiple grey level representation as is the Telidon pixel. The PEL either is on or off (black or white). By allowing a block of PEL's to define a pixel and turning on a set number of these PEL's on, pixels of different grey shades can be simulated.

The resolution of Facsimile is 1536 x 2004 PEL's. If this were square format the resolution would be about 2k x 2k PEL's. At present, the resolution of Telidon imagery is about 256x256 pixels in a square format. Comparing Telidon and Facsimile pages, there are about 64 times as many PEL's as pixels, or alternatively, a pixel can be represented by an 8x8 PEL block, then each square in the grid will be capable of taking on 64 different grey levels.

The grey level information from the pixel is then matched against the 64 available levels and the nearest match is used in the Facsimile transmission. The 64 levels can be represented in 6 bits. The SET COLOUR command (Figure 3-5) will have its operand bytes truncated and one byte containing the appropriate grey level inserted after the opcode (Figure 3-6). When the algorithm encounters this PDI at a further stage it will expect the grey byte and process it accordingly.

Although it is a subjective decision, it is assumed that a minimum of 16 grey levels are required to produce acceptable imagery. A 4x4 block of PEL's contains 16 grey levels. With this resolution there would be 512 pixels per Facsimile line. This scheme would handle the resolution of most current generation Telidon terminals. The Telidon philosophy dictates that in the event that the PDI information is of a greater resolution than that which the target device can handle, the PDI is to be truncated to the resolution of the target device. In the light of this philosophy, any PDI stream having a greater resolution than allowed by this Facsimile conversion algorithm will be truncated to the required resolution.

There is a trade-off between resolution and the number of available grey levels in the proposed scheme. However, current Telidon systems are based on a 256 or 512 pixel resolution screen which can be easily accommodated by this conversion scheme. If more than 512 pixel resolution is required without associated loss in grey levels, then anti-aliasing may be employed to increase the apparent resolution of the image.

This colour to monochrome conversion scheme will produce images with sufficient grey levels to represent the original colour image. By operating on the vector PDI commands, implementation complexity is kept to a minimum. Also, by using the PDI stream approach, the algorithm will be general in the sense that it will not be able to distinguish the source, be it a Telidon Terminal or Data Base.

Once the resolution of the Facsimile is chosen (ie either 8x8 or 4x4 PEL's per pixel), then the next point to consider is which PEL's get selected to be turned on or off when trying to achieve a particular grey level. One method might be to turn on PEL's starting from the upper left corner and progress to the lower right corner until the desired grey level is achieved. This method is simple to implement,

but will result in an image that will appear to be shifted up and to the left and may have also have distracting texture patterns. A method more pleasing to the eye would be to randomly select which PEL's within a pixel get turned on or off. A randomised selection ensures that there will be no underlying geometric texture associated with grey level generation to interfere with the image information. An example of a randomized PEL placement is found in Figure 3-7.

A compromise between the two halftone techniques mentioned above is to choose fill patterns that do not readily generate annoying textures or artifacts. A careful choice of patterns can eliminate halftone texturing and has a computational advantage over random pattern generation. A discussion of halftone techniques is found in Reference 30.

3.2.4 Character Grey Level Selection

Since the method described in Section 3.2.2 does not provide a unique mapping between colour and grey level there is a finite probability that two distinct colours will be represented by the same grey level. When representing character information, this may be a particularly annoying problem if the character colour and background colour end up being mapped into the same grey level hence rendering the characters invisible. To avoid this, it is suggested that characters always be represented as black on a white background regardless of colours assigned to each.

3.2.5 Accessing Telidon Information and Huffman Coding

This report has implicitly assumed that Telidon data is to be processed in its PDI form, as opposed to its raster scan or bit-mapped form. The rationale for doing so is the simplicity with which PDI information can be manipulated. All data manipulation required for the conversion process is relatively minor compared to the effort that would be required to process the raster encoded data. Coupled with this is the fact that raster encoded data is limited to the resolution of the hardware that is displaying the information.

Facsimile encoded information is a form of highly compressed raster-scan run-length coding called Huffman encoding. In order to transmit Telidon data to a Facsimile type receiver, it becomes necessary at some point to convert from Telidon codes, which are essentially vector codes, into Huffman codes. For the reasons cited above, this conversion is best left to the end of the process. There are available from several commercial manufacturers, including Imapro Inc., microprocessor based devices that will perform the conversion from Telidon PDI's to raster codes suitable for display on CRT terminals. Conversion from uncompressed raster codes into Huffman codes for transmission would require little extra development beyond what these packages already provide.



Figure 3-7 Example of an image reproduced on a Facsimile machine with grey levels implied by random PEL distribution.

3.2.6 End of Image Indicator

Current Telidon convention does not provide any method for indicating that a complete image has been transmitted or received. With a CRT based soft copy system the image is continuously updated as PDI's are received. The image is judged as complete by a viewer when it remains stable for a few moments. For hard copy systems a more stringent definition of the end of an image will be required. This point is discussed in section 2.

3.3 TELIDON TO FACSIMILE CONVERSION ALGORITHM

In order to make use of commercially available equipment it is suggested that the Telidon-to-Facsimile conversion be implemented as shown in Figure 3-8. The input to the system is the Telidon PDI codes. The output is Huffman codes suitable transmission to Group 3 or Group 4 Facsimile machines. "PDI Vector Conversion" is the modification of the Telidon vectors into a Facsimile compatible format; that is with colour information converted to an equivalent black-and-white representation, with vector coordinates rotated by 90°, and with PDI resolution truncated, if required. "Vector to Run-length Raster Conversion" is the process of converting the modified PDI vector description into a series of run-length encoded raster line description. "Run-Length to Huffman Translation" is the translation of the run-length codes (RLC's) into the Huffman format. Huffman coding is a RLC coding scheme optimized for character transmission.



Figure 3-8 Suggested implementation of the PDI to Facsimile conversion process.

3.3.1 PDI Vector Conversion

The following algorithm describes a process that accepts a stream of PDI's as input and modifies the vector information for presentation to the vector-to-raster preprocessor. This phase produces a Facsimile compatible PDI stream, that is, with colour information modified to an equivalent black and white representation, with vector coordinates rotated to account for the Facsimile page's aspect ratio, and with PDI resolution truncated, if required. As each input PDI data byte is received it is processed into an output buffer according to one of the four categories below:

1. Opcodes with colour information
 - Set Colour
 - Select Colour
 - Reset
2. Opcodes with vector information/other operands
 - Line, Point, Arc, etc.
3. Character codes
 - Standard ASCII
 - Supplemental character set
4. Control codes
 - S0
 - S1
 - SS2

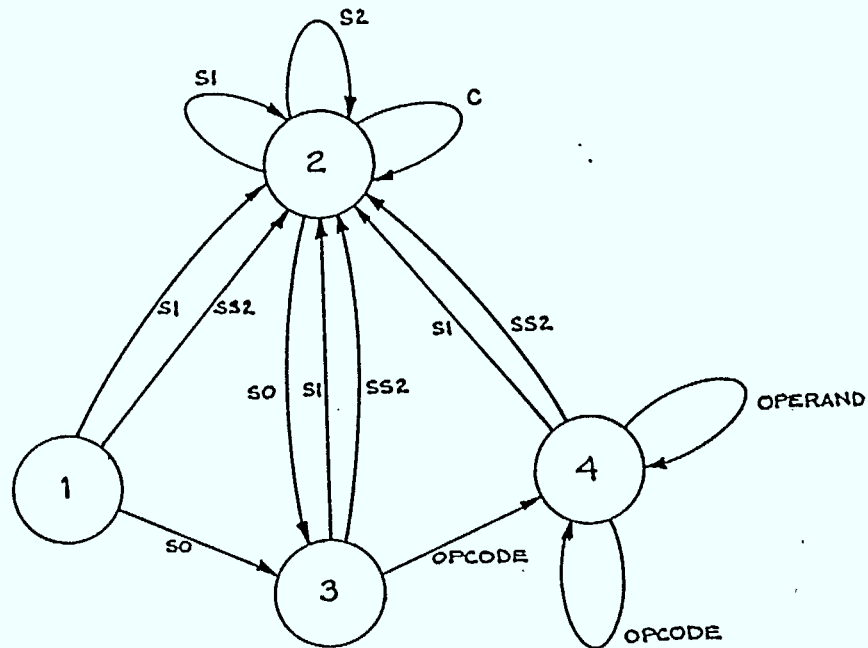


Figure 3-9 State diagram for the processing of PDI's in preparation for transmission to a Facsimile type device

The state diagram of Figure 3-9 illustrates the effects of each of these categories. Opcodes with colour information are of two types: those with direct colour information, such as SET COLOUR, and those with colour map locations, such as SELECT COLOUR. When an opcode with direct colour information is identified (ie. SET COLOUR), following operands in the data stream are read until the next non-operand byte is encountered (Figure 3-10). The colour information is extracted from these bytes and the luminance is calculated using the relation given in Section 3.2.2. The calculated grey level is mapped against the table of allowable grey levels to find the closest match. The matching grey level code is added after the opcode as the only operand, and the two byte pair is placed in the output buffer.

The SELECT COLOUR opcode has two, one, or no following operands depending on the mode (Figure 3-11). Upon detecting a SELECT COLOUR opcode, the following operands, if any, are read. If there is no following operand then the opcode is stored in the output buffer. If there is a following single byte operand, then the operand is treated as the address of a colour in the colour map. This address is mapped into the intended grey map. The address of the grey shade is substituted into the operand. The opcode and the modified operand are then placed in the output buffer. If there are two bytes following the opcode, then the operands specify a background colour and a text colour address. Since all text in this algorithm will be defined as black characters on a white background, the second operand byte is ignored.

Non-colour opcodes are processed for vector information (Figure 3-12). If the opcode is not a vector opcode then it is put directly into the output buffer along with any associated operands. If the opcode contains vector (x-y) information, then the operands are read from the PDI stream until a non-operand character is encountered. The x-y coordinates are rotated according to the equation of Section 3.2.1. The opcode and modified operands are stored in the output buffer.

The characters supported by Facsimile will include both the ASCII and Supplementary G sets (Figure 3-13). Each of these characters has a unique description composed of PDI's. When a character is detected, its code in conjunction with the present in-use G set are uniquely mapped to a location that contains an address and a length. The address is the start of the PDI string that describes this rotated character, while the length is the number of bytes contained in the PDI description. These bytes are then inserted into the output buffer. This procedure is based on the assumption that the character sets are in their default G sets and the in-use G set is known. This algorithm supports the PDI, ASCII and Supplementary default G sets only. A control code is used to identify what type of command to expect in the next character (ie. PDI or character). The control code is not saved, but its value is used to determine the in-use G set. This is necessary to distinguish between the two supported G sets.

To ensure the positional integrity of characters with respect to the rotated image, the coordinate transformation (section 3.2.1) is applied to the character coordinates. To ensure proper orientation of the characters, the PDI character description table (Figure 3-13) describes the characters within the rotated frame.

3.3.2 Vector to RLC Raster Conversion

The next step in preparing a Telidon image for Facsimile transmission is to convert the vector image description into a raster image description. A vector image description is a very compact, "human" form of description, attractive to those who create the images; however, most hard copy devices such as film recorders or ink-jet plotters require a raster-type description. The process of converting vector to data to raster data is becoming a topic attracting considerable research and development, and there are an increasing number of processors that are becoming available that can convert vector data into raster data. One such unit is the Imapro Quick Vector Processor™ (QVP™) which is described below.

The QVP™ is a microprocessor based system. It accepts an entire vector image description, processes it, and outputs the Run Length Code (RLC) equivalent of the image. The processing consists of sorting temporarily (i.e. with respect to an objects position within the input data stream) and positionally (i.e. with respect to an objects physical position in the output image) the vector descriptions of the individual objects that makeup the image into a vector list. The sorted vector object list is then converted.

one raster-line at a time into RLC's. The rasterization process starts in the upper left-hand corner of the image and terminates in the lower right-hand corner. As each line is processed, the vector list is checked. If an object starts on the current raster line, it is added to the list of objects actively being converted. The active object list is converted into a series of run-length codes for each line of image.

Each RLC consists of two bytes (16 bits). The first byte specifies the duration of a given line segment. The second byte specifies the colour.

Currently, the QVP only accepts vector image descriptions described in its internal meta language called "SCODL". However, it is anticipated that the QVP will soon support several high-level description languages, including Telidon 709.

3.3.3 Run Length to Hoffman Translation

The output of the QVP, which is typical of processors of its type, is a series of RLC's. Each code is of a fixed length: eight bits describing duration and eight bits describing intensity. Hoffman codes, on the other hand, employ a variable word-length coding scheme, with only the duration explicitly specified. Before QVP RLC codes can be transmitted to facsimile equipment, they must be translated into Huffman codes. As an example, Table 4.1 provides the translation for the numbers 0 to 63 into Huffman codes.

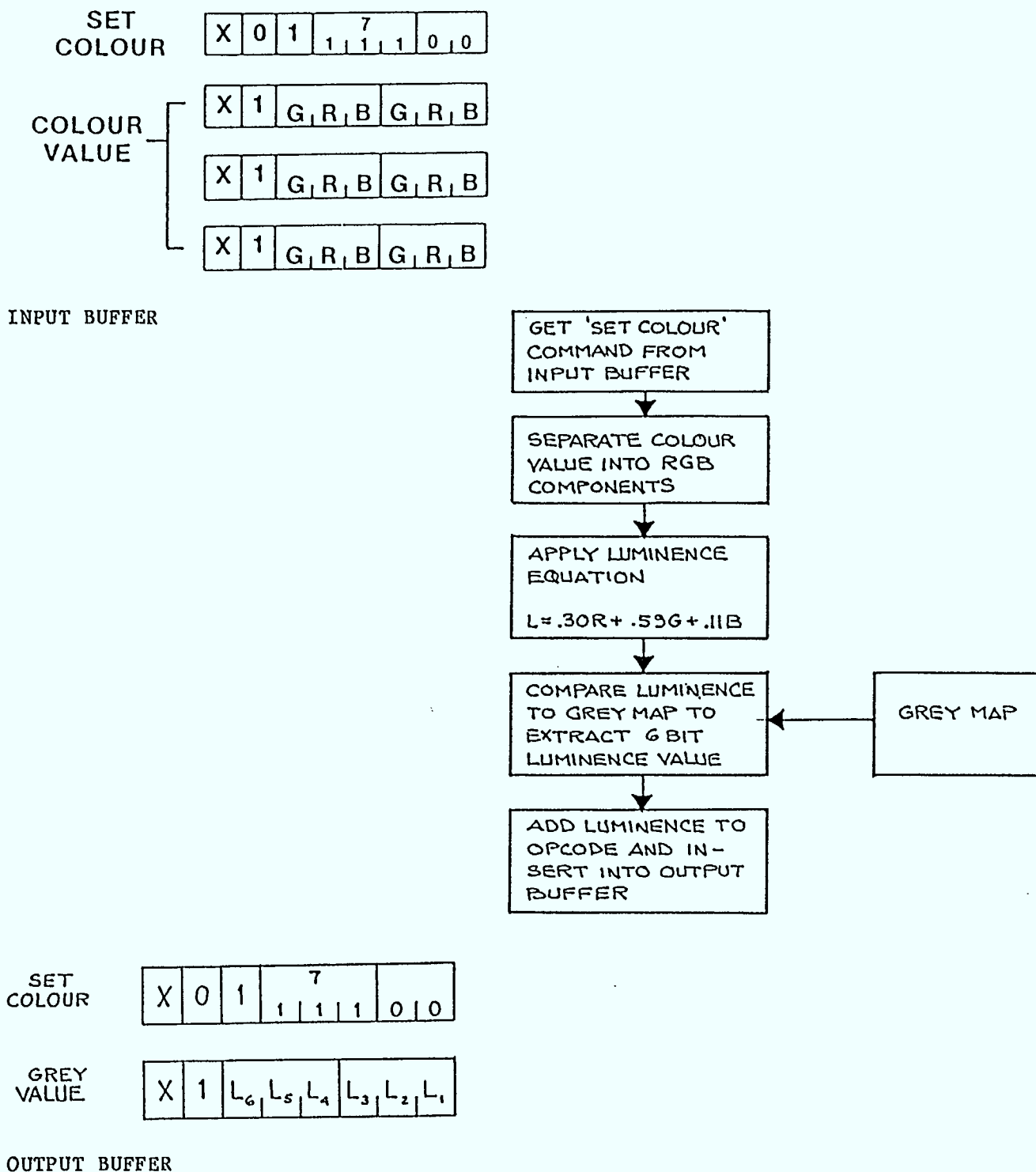


Figure 3-10 Algorithm for modifying the SET COLOUR command to specify grey levels.

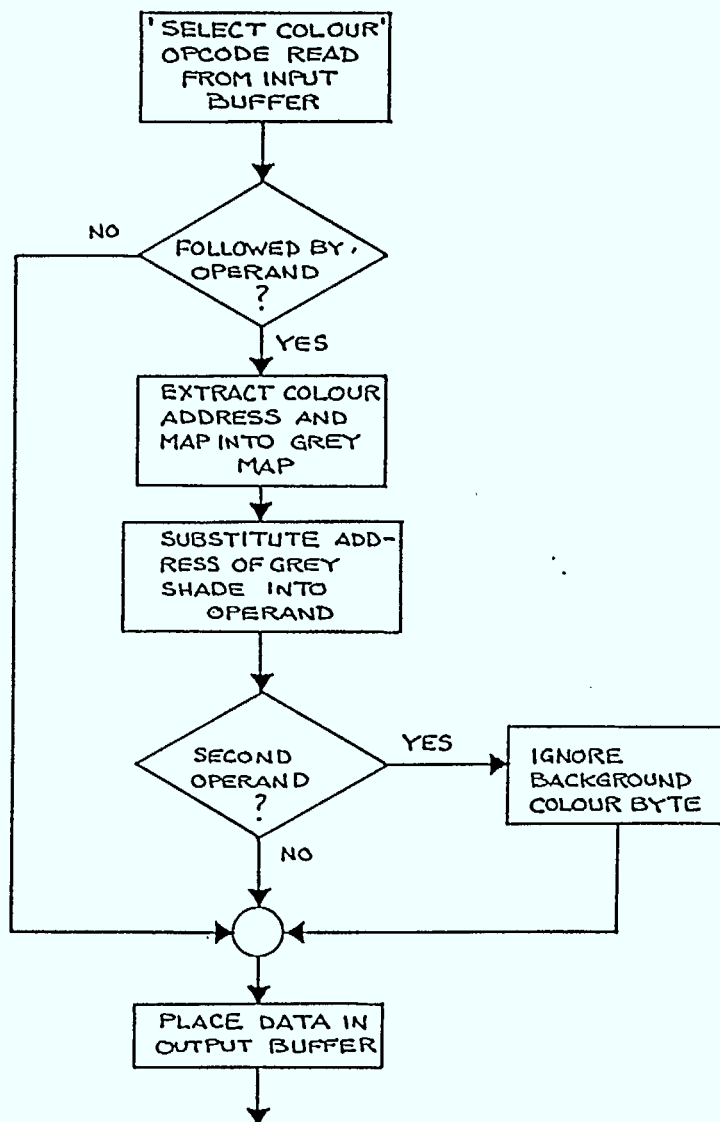
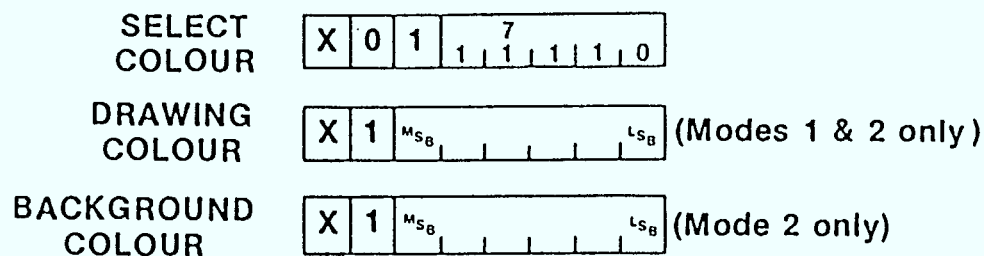


Figure 3-11 Algorithm for modifying the SELECT COLOUR command to specify grey level.

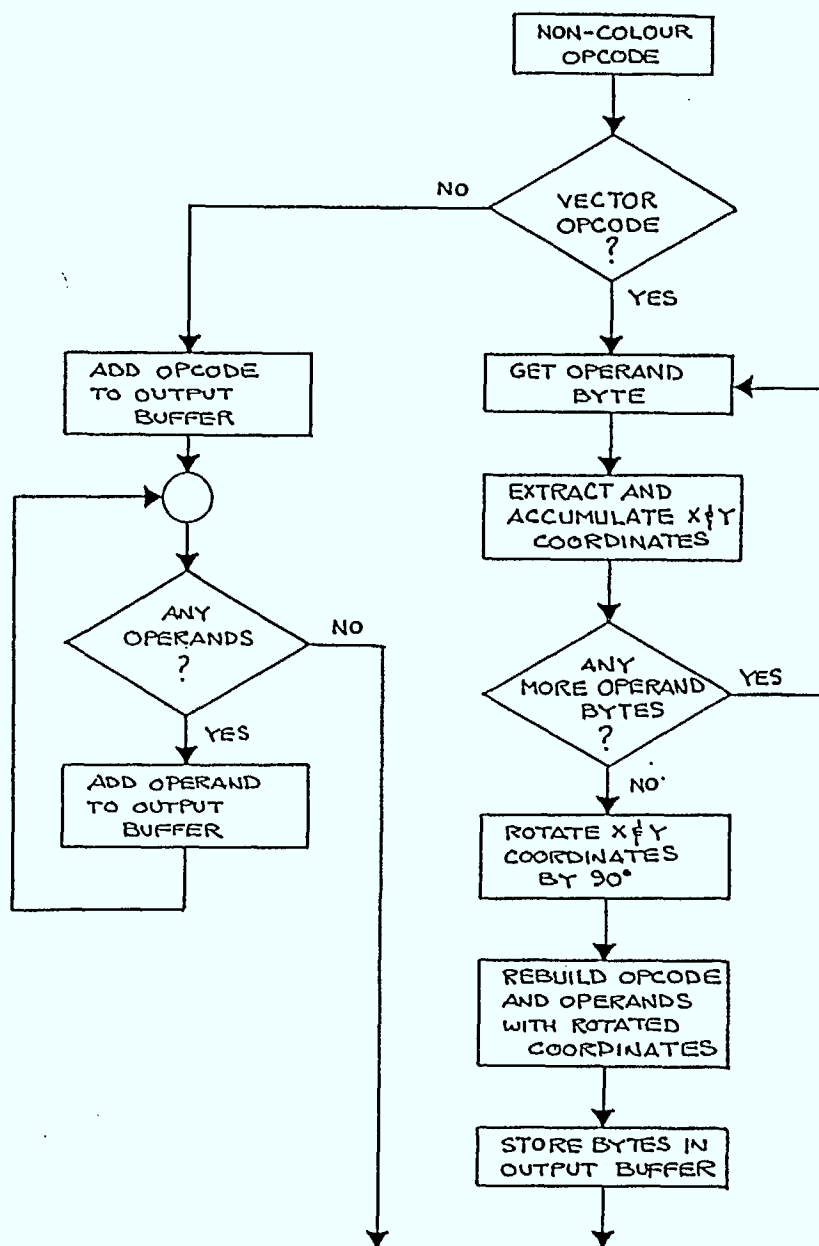


Figure 3-12 Algorithm for modifying vector type PDI commands by rotating coordinates.

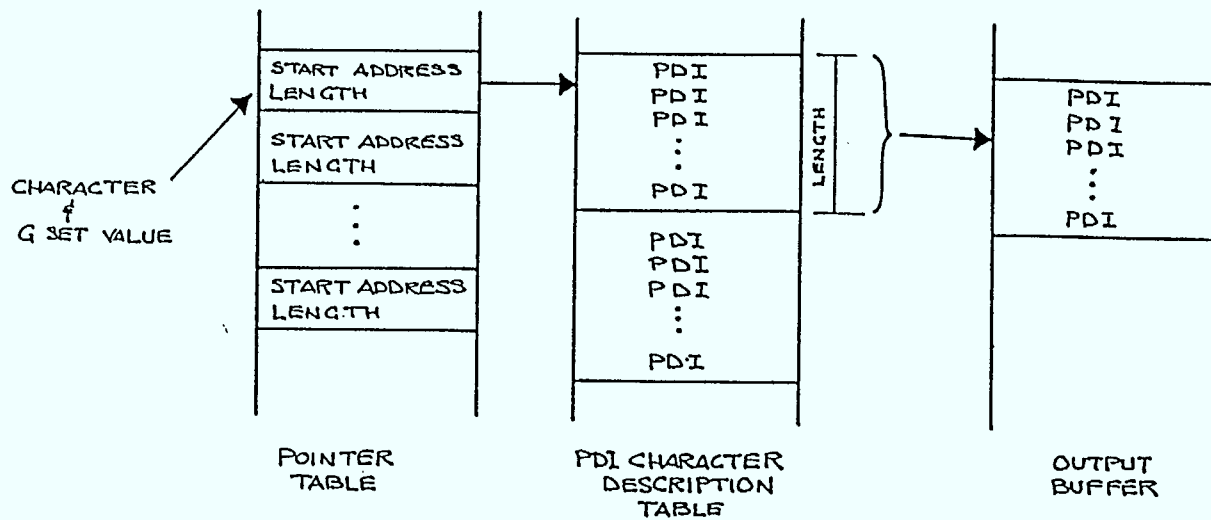


Figure 3-13 Algorithm for converting characters into PDI vector lists.

4.0 FACSIMILE TO TELIDON CONVERSION

This section of the report discusses the conversion of Facsimile code into a form suitable for Telidon imaging. This section is divided into two sub-sections. The first of these discusses the display of Facsimile information on a Telidon terminal, while the second examines methods of conversion between Huffman codes and Telidon PDI's.

4.1 THE DISPLAY OF FACSIMILE DOCUMENTS IN THE TELIDON MEDIA

Displaying a Facsimile document on a Telidon CRT is essentially a problem in displaying more information than can be output on a single Telidon screen. This section discusses the problems associated with the different aspect ratios of Telidon and Facsimile, the Telidon screen display capacity, and image segmentation for display purposes.

4.1.1 Aspect Ratio

If one were to try to image an entire North American standard size facsimile document on a Telidon screen, because of the differences in aspect ratios between Facsimile and Telidon, one would be limited to the use of approximately 9/16 of the Telidon screen area (Figure 4-1). As discussed in Section 3.1, the aspect ratio for a Telidon screen is 4:3 and the aspect ratio of a standard Facsimile document is 3:4. The solution proposed in Section 3.2.1, that of rotating the Telidon image by 90 degrees, is not applicable here because subjecting a Facsimile image to such a rotation would result in the image appearing similarly rotated on the Telidon screen. To display the Facsimile document, the usable aspect ratio of the Telidon screen must be limited to 3:4. This is accomplished by limiting the usable width of the screen to 9:16 of its nominal value.

If a Telidon screen has a resolution of 256 x 200 pixels, this results in the useable screen area being limited to 200 x 144 pixels.

4.1.2 Character Information Capacity

A Facsimile document is capable of containing a far greater amount of character information than can be displayed on a single Telidon screen. Consider a standard sized Facsimile document that has 12 characters per 25.4 mm, a line spacing of 4.23 mm, and useable area of 195 x 260 mm. For these dimensions there would be 92 characters per line and 61 lines for a total of 5612 characters. The current standard full size Telidon screen is capable of nominally supporting 20 lines of 40 characters each, for a total of 800 characters. A single Facsimile page of the above specifications would require the equivalent of 7 Telidon screens to display the same amount of character data. If the original Facsimile document had contained 15 characters per 25.4 mm, then 9 Telidon pages would be required, and typically, Facsimile

machines have no problems dealing with characters densities of 20 characters per inch and higher.

This discussion has implicitly assumed that the Facsimile character information can be converted from raster scan into ASCII for optimum compression and display on a Telidon screen. If the Facsimile character data were left in its raster scan form, then considerably less Facsimile data could be displayed per Telidon screen.

Therefore, in order to display a Facsimile document of a Telidon screen, it would be necessary to devise a method of scrolling or paging the information onto the screen. Even with such methods, the task of reading a one page document would become an awkward exercise of sorting through multiple screens of text.

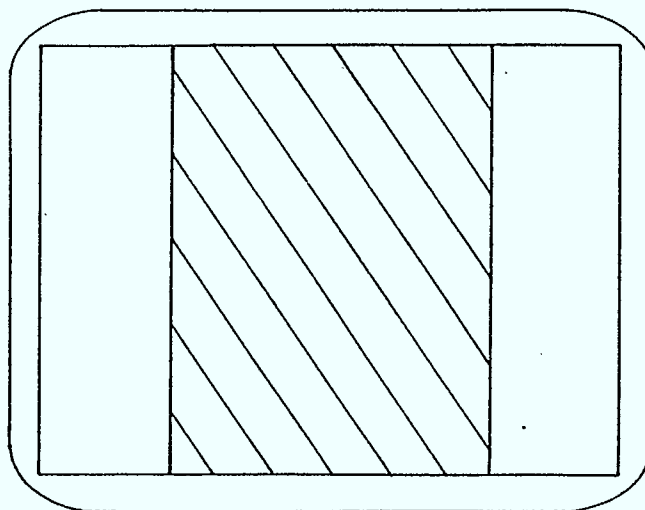


Figure 4-1 Useable Telidon screen area for the display of a complete North American standard size Facsimile document indicated by the shaded area.

4.1.3 Geometric Information Capacity

If the method of using multiple Telidon screens is applied to geometric images (ie. drawings, non-character data, etc.), then a similar problem arises. At full resolution, it will be possible to view the Facsimile image only in a segmented form, with each segment being equal to the resolution of a Telidon screen. Assuming a Telidon resolution of 250 x 200 pixels and a Facsimile resolution of 1567x 2002 PEL's, a Telidon screen is capable of resolving 51200 pixels, while a Facsimile page contains over 3 million PEL's. This implies that it will require 61 Telidon screens to display a full Facsimile image. No matter what type of screen manipulation is available, an image that is segmented into 61 sections is impossible to view. Therefore, to obtain an image that is entirely visible on the Telidon screen it will be necessary to decimate the resolution of the Facsimile image. By doing this, a low resolution representation of the image may be entirely

displayed on a single Telidon screen. However, the decimation of the image will make any text information illegible.

4.1.4 Compression Techniques

In order to decimate an image without loss of text legibility, a character recognition and extraction technique known as Optical Character Recognition (OCR) may be employed. Using this technique, character information may be stripped from the image before decimation. The text may be reinserted back onto the screen after the image is decimated and displayed. However, the same rates apply to text here as before. The Telidon text handling capacity is limited to 800 characters per screen. This limitation gives rise to two problems. There is a possibility that the amount of text contained in the Facsimile document will exceed 800 characters and consequently not be reproducible on a single screen. The second problem involves the positional integrity of the characters. As the variation of Telidon character size and numbers are limited it will not necessarily be possible to replace the text in the same location on the decimated image as on the original Facsimile document.

The discussion has centered around the mapping of high resolution Facsimile to a low resolution Telidon terminal. The use of higher resolution terminal could serve to reduce some of these problems. Currently, the upper limit on colour CRT resolution is 1000x750 pixels, for a total of 750000 pixels. At this resolution, it would require four Telidon screens to image a standard Facsimile page. While the severity of the problem would be considerably reduced, this solution would still require some segmentation of the image. Coupled with this is the fact that CRT costs increase dramatically with increased resolution.

The use of a high resolution CRT with OCR techniques may provide satisfactory results under certain circumstances. A 1000 pixel resolution monitor could display up to 160 characters per line. This ability would satisfy most Facsimile document requirements in terms of horizontal resolution. Vertically, approximately 48 lines could be viewed comfortably, implying that a document would still have to be scrolled to be viewed in its entirety.

The Telidon screen media is not necessarily the optimum display medium for a Facsimile document. The Facsimile media is a hardcopy media and it follows that the output should be targeted at a hardcopy device. The range and uses of hard copy devices are discussed in section 5. Briefly, a workstation capable of handling Facsimile type documents would be composed of the Telidon Terminal and a low cost printer. A decimated version of the Facsimile document would be displayed on the terminal, say for identification purposes, while the full resolution version would be obtained from the printer. This configuration would provide the document in a convenient form, with no resolution or capability compromises, at a reasonable cost. Line printers, with adequate resolution for Facsimile documents, are available at low cost. Using these devices will provide full resolution copies of the original Facsimile message

4.2 HUFFMAN TO PDI CONVERSION TECHNIQUES

This section discusses the methods available to convert the raster-scan Huffman codes to the vector structure Telidon PDI code. Two groups of conversion schemes are discussed: Alpha-photographic and Pattern Recognition conversion. Each of these methods have their strengths and weaknesses. Topics to be discussed include ease of implementation, speed of conversion, compression capabilities and areas of implementation.

4.2.1 Alpha Photographic PDI's

The alpha-photographic conversion scheme directly converts Huffman codes (Ref.3) to their PDI run-length equivalents. Huffman encoding describes each raster line of a document in terms of a series of variable length black and white segments (Table 4-1). The coding scheme has been optimized for the description and transmission of character-like data with a minimum number of bits. Alpha-photographic conversion consists of translating the Huffman run-length description into a series of PDI LINE commands (Figure 4-2). Each Huffman run-length would be translated into a LINE command of two or more bytes, depending on the relative horizontal displacement. Figure 4-3 gives the conversion for a typical Huffman black run-length into a PDI LINE command. It can be seen that it requires two bytes of LINE command to describe what requires two bits in Huffman coding. The order of magnitude of this increase in the number of bits required to translate a Huffman encoded image into alpha-photographic PDI's is typical.

4.2.2 Direct Acceptance of Huffman Codes

Another possibility for alpha-photographic conversion is the creation of an escape sequence in Telidon that would allow a terminal to directly accept Huffman codes. If a terminal were to receive this escape sequence, it would know that the following data was Huffman encoded. When it received the same escape sequences a second time, it would switch back to Telidon compatible data mode.

While in the Huffman mode, the transmitting device would check for Huffman codes that could be misinterpreted as an escape sequence by the receiver. When such data sequences occur, an extra escape sequence would be inserted immediately after the first sequence. The receiver would check for pairs of escape sequences. When found, the receiver would treat the first sequence as data and ignore the second. A single escape sequence would toggle the system back into Telidon mode.

The advantages of this technique are that it is very simple to implement and it provides very good data compression, especially for character type data.

4.2.3 Pattern Recognition

Pattern recognition is not a specific method, but rather a family of methods having certain similar characteristics. The purpose of pattern recognition is to extract pattern data from a general image. Two methods of pattern recognition that have application in Facsimile to Telidon conversion are Optical Character Recognition and Polygon Extraction. Optical character recognition, OCR, involves matching incoming data against a family of known patterns. This method provides optimum compression for character data and also provides the advantage of converting data into a form that can be processed by other data processing systems such as word processors.

The disadvantage to OCR is that it must be "trained" handle each different character font, making it more sensitive to errors than other conversion techniques.

Polygon Extraction does not attempt to match data against a known set of patterns, but instead attempts to identify polygon boundaries. Polygon Extraction results in an image being described as a mosaic of simple polygons.

The application of pattern recognition techniques to Facsimile images is an involved task. The entire Facsimile document must exist in a bit-mapped form. Two dimensional pattern recognition algorithms are then applied to this map in an attempt to define and extract polygon and character information. Polygon information is then translated to a vector PDI format through the use of the POLYGON PDI commands. Character information is replaced by the matching character from the Telidon repertoire.

The amount of data compression using pattern recognition is not as good as with Huffman codes. However, pattern recognition does offer the largest amount of compression for any Telidon based image description method.

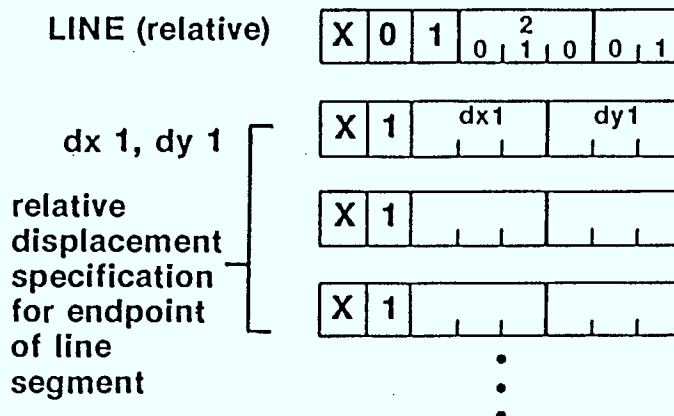


Figure 4-2 PDI LINE command

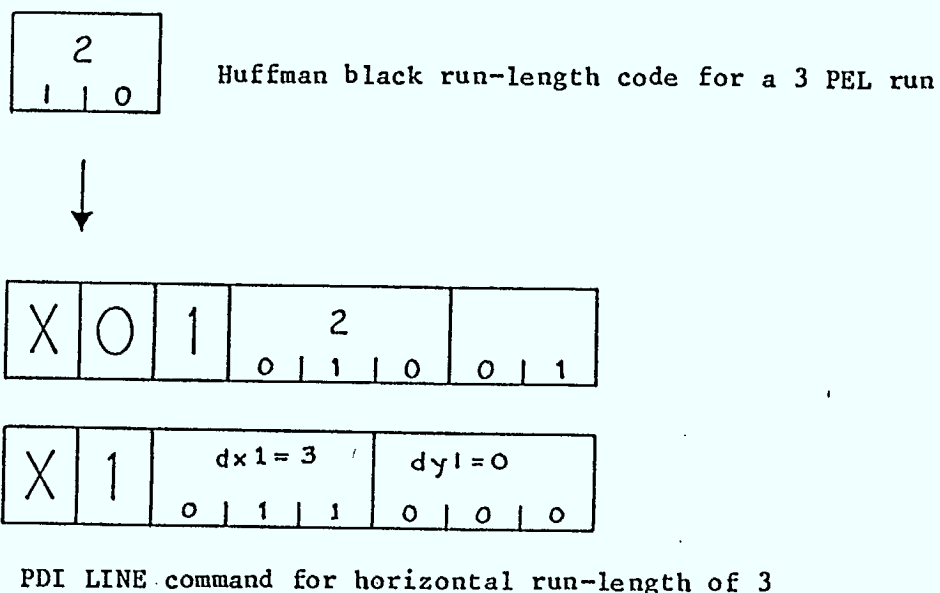


Figure 4-3 Comparison of equivalent Huffman and PDI run-length commands

4.3 A COMPARISON OF CONVERSION METHODS

The alpha-photographic conversion scheme is best suited for dedicated terminal applications, while the Pattern recognition techniques are more suited to gateway applications. In terms of cost, the development of an alpha-photographic system is very inexpensive when compared to that of a dedicated pattern recognition scheme. The low cost makes the alpha-photographic conversion scheme more economical to implement on a single terminal. Conversely, the pattern recognition system is most economically situated in a network where the cost is spread out among terminals.

The conversion speed of an alpha-photographic system is likely to be greater than that of most pattern recognition systems. Alpha-photographic system converts the information directly, while pattern recognition schemes attempt to impose some structure on the image. The imposition of structure tends to consume a considerable amount of processing time, certainly more than direct interpretation. The importance of the time trade-off is lessened when images are translated for archived storage in Data Base.

The amounts of data compression possible with pattern recognition techniques far exceeds that of the Alpha-photographic method. To illustrate this, compare the number of bytes required to describe the letter "O" via OCR techniques versus alpha-photographic techniques. If the letter is 2mm high on the Facsimile document, then it will be broken into 16 separate scan lines. Each scan line will require approximately four black-to-white and white-to-black transitions (ie four run-length codes). If each PDI run-length requires 2 bytes

(Section 4.2), then it will require 128 bytes (16 scan lines x 4 runlength codes x 2 bytes) to describe the letter using alpha-photographic technique. The OCR technique directly recognizes the character and translates to a G-set representation, which requires a single byte.

From this example, it can be seen that OCR provides a 128:1 data compression over alpha-photographic descriptions. This result is typical of the compression that can be achieved. Even when compared to Huffman coding, OCR still will provide a data compression of 16:1

The Pattern recognition scheme represents a considerable cost saving if archival storage of Facsimile documents are required. The above example illustrates that memory requirements may be reduced by orders of magnitude when a properly conceived pattern recognition scheme is used. This type of conversion lends itself well to gateway type applications, where unit cost may be distributed throughout a network.

Alpha-photographic methods are most suitable where permanent storage of information is not required. Since the translation process is relatively simple, it can be performed directly by the terminal.

4.4 PAGE CREATION AND STORAGE

One possible use of Facsimile to Telidon conversion is the in the area of page creation. A facsimile machine may be used as a scanner with the Facsimile data then converted to Telidon format for storage within a data base. As per previous discussions, there are several methods by which data can be processed prior to storage: alpha-photographic, Huffman, optical character recognition and polygon extraction. The choice of processing method is data dependant. For character data a choice of OCR a Huffman encoding is appropriate. For graphics type information alpha-photographic or polygon extraction processing would be the logical choice.

The amount of human interaction desired also affects the choice of processing. For a completely automated system, the processing techniques would have to be robust, data independent, and hence simple. The choices would be alpha-photographic or Huffman encoding. For a semi-automatic system, where an operator could section off portions of an image for different types of processing, OCR and pattern recognition techniques would provide optimum compression and would simply future image manipulation. The following are two proposed creation systems:

4.4.1 Automatic Page Creation System

An automatic page creation system would operate entirely without operator intervention. To avoid corruption of the image, very little processing would be done on the data prior to storage. Data would be stored directly as Huffman codes or translated to alpha-photographic codes.

The advantages of such a system are that it would be fast, inexpensive and the image quality would not suffer from the data translation process. If Huffman codes are used, good data compression can still be achieved.

The disadvantages are that data stored in such a format is difficult to manipulate. If information must be extracted from a portion of the stored image, it must be further processed.

The amount of effort required to develop such a system is minimal. If Huffman codes are to be stored directly, an escape sequence delimiting Huffman code image data must be established. If the Huffman codes are to be converted alpha-photographic PDI's, then a translator needs to be developed.

4.4.2 Semi-Automatic Page Creation System

A semi-automatic creation system would require an operator to preview Facsimile data and on the basis of image content choose an appropriate coding scheme for storage. This system would require a high resolution display and light pen or graphics tablet of some sort. With these tools, the operator would block off images into areas of character graphics and photographic (grey level) data.

For character data, OCR techniques would be applied and character data converted to ASCII. For character fonts that the OCR system had difficulty with, the operator would optionally input the correct spelling via keyboard, or designate that the area be stored as Huffman or alpha-photographic codes.

For geometric objects (graphics), the operator would apply generalized polygon extraction techniques to extract? polygon information. For photographic areas, alpha-photographic conversion could be applied.

The advantages of such a system are that it provides maximum data compression. It would be relatively easy to further manipulate the data. the operator could improve or enhance the data.

The disadvantages are that such a system is slow, complex, expensive, and subject to human error.

To develop such a work-station would require the integration of a high-resolution graphics system, OCR system, pattern recognition system and Facsimile system into a Telidon terminal. Even though all of the above are available commercially, a significant effort would have to be put into hardware and software development. Because of the cost of such a system, it would be best used as a shared resource, implying some sort of gateway.

White run length	Code word	Black run length	Code word
0	00110101	0	0000110111
1	000111	1	010
2	0111	2	11
3	1000	3	10
4	1011	4	011
5	1100	5	0011
6	1110	6	0010
7	1111	7	00011
8	10011	8	000101
9	10100	9	000100
10	00111	10	0000100
11	01000	11	0000101
12	001000	12	0000111
13	000011	13	00000100
14	110100	14	00000111
15	110101	15	000011000
16	101010	16	0000010111
17	101011	17	0000011000
18	0100111	18	0000001000
19	0001100	19	00001100111
20	0001000	20	00001101000
21	0010111	21	00001101100
22	0000011	22	00000110111
23	0000100	23	00000101000
24	0101000	24	00000010111
25	0101011	25	00000011000
26	0010011	26	000011001010
27	0100100	27	000011001011
28	0011000	28	000011001100
29	00000010	29	000011001101
30	00000011	30	000001101000
31	00011010	31	000001101001
32	00011011	32	000001101010
33	00010010	33	000001101011
34	00010011	34	000011010010
35	00010100	35	000011010011
36	00010101	36	000011010100
37	00010110	37	000011010101
38	00010111	38	000011010110
39	00101000	39	000011010111
40	00101001	40	000001101100
41	00101010	41	000001101101
42	00101011	42	000011011010
43	00101100	43	000011011011
44	00101101	44	000001010100
45	00000100	45	000001010101
46	00000101	46	000001010110
47	00001010	47	000001010111
48	00001011	48	000001100100
49	01010010	49	000001100101
50	01010011	50	000001010010
51	01010100	51	000001010011
52	01010101	52	000000100100
53	00100100	53	000000110111
54	00100101	54	000000111000
55	01011000	55	000000100111
56	01011001	56	000000101000
57	01011010	57	000001011000
58	01011011	58	000001011001
59	01001010	59	000000101011
60	01001011	60	000000101100
61	00110010	61	000001011010
62	00110011	62	000001100110
63	00110100	63	000001100111

Table 4-1 Huffman black and white run-length codes

5.0 TELIDON HARDCOPY

This is a survey of the types of commercially available devices suitable for Telidon hardcopy. The hardcopy device is a vital output for all work stations. Despite the information revolution brought about by the explosive growth of the semiconductor industry, the printed media still plays a dominant role in the work-place. This trend is not expected to abate in the near future, and perhaps not for decades.

The sheet of paper or photographic film is a robust and versatile medium. It provides ease of storage and access coupled with display formats limited only by the imagination. The present CRT display type technology cannot make the same claims. The display technology places severe limits on the ease of display and portability of an image. While the semiconductor revolution has made mass data storage inexpensive, image display is limited to locations having a terminal; hardcopy does not suffer from this constraint.

In the wake of the first wave of the semiconductor revolution an increased demand for colour hard copy has arisen. The demand for quality business graphics has grown at a rate equal to the rate of growth of the hardcopy technology. Other areas such as the graphic arts field, are demanding better hardcopy devices as traditional methods are replaced by the more efficient techniques offered by the new technologies.

As Telidon becomes established as a North American standard high quality colour hardcopy becomes a necessity. Recent studies have shown that among the users of computer graphics equipment 20% are using colour hardcopy for the images. The demand for this output is expected to rise by 30% in the near future. Business graphics, an area where Telidon can excel, are listed among the most common uses of colour.

5.1 REQUIREMENTS OF A TELIDON HARDCOPY SYSTEM

Within the context of this report, a hardcopy system would have to handle Teletex, Facsimile, and Telidon data. These are diverse requirements, and it is not likely that any single output device will be cost-effective in handling all three requirements. For Teletex, a serial printer which supports the appropriate character sets is sufficient. For Facsimile, a printer/plotter of some type is all that is required. For Telidon, a full colour recorder of some type is required.

The following discussion divides hardcopy devices into three broad classes, categorized by cost. The suitability of each class of hardcopy to one or more of the above requirements is discussed. A summary of the types and price ranges of hard copy devices currently available is given Tables 5-1 and 5-2. This information was obtained from an IGC conference recently attended by Imapro Inc.

5.1.1 Low End Printers

The low end printer is typically less than \$2000 in price, and can be obtained for as little as several hundred dollars. Its print mechanism usually consists of a wire-matrix print head mounted on a sliding horizontal carriage. Some printers have programmable character fonts while others can be used as plotters as well as printers. Normally, these printers can print only in black and white.

Printers of this class are quite adequate for handling Teletex information. They are reasonably fast and use ordinary paper. Support for the full Teletex character set can be ensured by selection of a printer that has programmable character fonts.

Facsimile can also be supported by this class of printer provided that it has plotting capability and 1500 pixel horizontal resolution. A serial print head will not be able to keep up with Group 3 Facsimile data rate, hence data buffering will be required.

As these printers only print in black and white, they are of limited use for displaying Telidon colour graphic information.

5.1.2 Colour Graphic Printers

The focus of development for hardcopy devices has been on Colour Graphics Printers and, as a result, there is a wide variety of devices available. The performance offered by these hardcopy devices is varied and this is reflected in their price range; \$5000 to \$16000.00.

Impact printers can be used for simple business graphics, as well as for text applications. The use of impact printers for graphics is usually in areas requiring low plot volumes, as these plotters are not overly rapid. Colours are produced by the use of multicolour ribbons, thus limiting the range of colours available. The unit cost of these devices is in the \$10,000. range and the cost per image is about 20 cents. The impact printer is suited for use in basic graphics systems where low cost is necessary and the limited colours, speed and resolution are acceptable.

Pen Plotters offer high quality, high accuracy line graphics. These devices are most cost effective in applications which require high quality line graphics on a variety of different page sizes. The cost of a pen plotter is in the \$5000 range and individual images are in the 6 cent neighbourhood.

The pen plotter is limited in speed and selection of colours. The speed limitation is due to the mechanical movement of the pen, while the colour is limited to the choice pen colour. Shading can improve colour ranges but speed is greatly reduced.

Ink-jet printers can provide fast, high quality images. These devices provide both line and solid area coverage and can simulate continuous tone images. This is a young technology and it has been plagued by reliability problems. Nozzle clogging and ink drop ballistic problems are the chief limitations imposed on these devices. The colour retaining properties of the ink dyes is also a problem, as the dyes tend to fade and this reduces the useful life of the document.

This technology holds much promise and as a result substantial effort has been directed at solving these problems. The unit cost of such a device is about \$6000 and image cost is 10 cents, making this an attractive hard copy device.

Newly introduced Electrostatic plotters are capable of high speed, high quality full colour images. These plotters can produce line graphics, solid areas and simulate continuous tone colour. Colour is achieved by using coloured toners in these plotters. The device cost is \$9000 and image cost is four cents.

Colour graphics printers can be used for all three applications, Teletex, Facsimile and Telidon. Hardware and software would need to be developed to support Facsimile Huffman code and Telidon PDI translation.

5.1.3 Colour Recorders

Colour recorders covers a broad variety of imaging systems. These systems usually consist of a scanning light source, an optical focusing system and photosensitive colour film. Film is exposed to the light source and is then chemically developed to produce the final image. Colour recorders vary in price from as little as \$5000 to as much as \$500,000. Because of the cost of film, and the time associated with processing an image, colour recorders are not appropriate output devices for Teletex or Facsimile information. They are, however, the ideal choice for Telidon hardcopy. Colour recorders are available with 4K pixel resolution or higher. Colour film provides excellent colour fidelity, wide density range, and long shelf-life.

One colour recorder particularly well suited to Telidon applications is the Imapro Quick Colour Recorder™ or QCR™. This recorder costs approximately \$30000, making it one of the least expensive colour recorders. It has 4K pixels horizontal resolution and has selectable output format of 35mm slide or 4x5 sheet film. The QCR™ is basically a raster scan type device but a processor is available that will accept Telidon PDI's and convert them into run-length codes that can be imaged on the QCR™.

5.2 RECOMMENDATIONS FOR TELIDON HARDCOPY

A Telidon terminal dedicated to the task of Facsimile or Teletex reception will require the minimal configuration hard copy device. For these applications a low end wire-matrix type printer is adequate. A low end printer will offer the economy and performance required for this application. If the terminal must also possess a colour capability, there are low end ink-jet printers that will provide the necessary resolution for Facsimile/Teletex and at the same time provide limited colour capability.

Higher quality hardcopy devices will become necessary as the Telidon terminal is required to perform more general printing tasks. Colour graphics printers are required to fulfill these demands. The

actual choice of printer type depends on the application. A selection of printer types is discussed in Section 5.1.2. From among these, the most popular is the impact printer followed by the ink-jet printer. Ink-jet printers appear to be the general purpose printer of the future because of their capabilities, and they are excellent devices for Telidon applications which require both quality colour graphics and Facsimile/Teletext capabilities.

Very high resolution graphics require the use of a colour recorder. The cost per image is a limiting factor for Facsimile/Teletext applications. The high cost of a colour recorder can be distributed among many Telidon terminals if these recorders are used as central hard copy devices for local Telidon networks.

Ink-jet printers will also serve well as the high quality output device for a network of Telidon terminals. While, at present, not capable of as high quality images as a colour recorder, they do offer considerably reduced cost per image price.

5.3 DEVELOPMENT AREAS FOR TELIDON HARDCOPY

The printers discussed are raster-scan type devices that must interface with Telidon vector type commands. Figure 5-1 is a block diagram that illustrates the required steps necessary to convert a PDI stream to raster-scan form. All the devices or algorithms are commercially available except for the Intermediate Processing block. Development is required to implement this block.

Telidon PDI commands must be properly configured to interface with the Vector to Raster conversion block. Every vector-to-raster conversion algorithm will have individual input requirements that vary from the PDI specification, some trivial and some significant. It is the task of the Intermediate Processing block to perform the necessary reconfiguration. Areas that may require this sort of attention include the processing of colour information, resolution differences and allowable character sets. Another area might include the processing of varied aspect ratios.

The operation performed by the Intermediate Processing block is entirely analogous to the first phase of the Telidon to Facsimile conversion algorithm presented in Section 3.

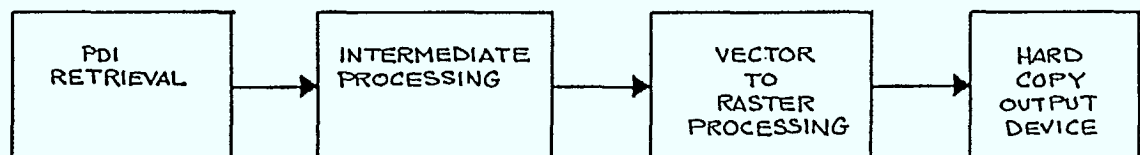


Figure 5-1 Necessary steps to convert a PDI data stream to raster scan form.

	CAPABILITY	HARDWARE COST	IMAGE COST	INTERFACE
IMPACT PRINTERS	OCCASIONAL GRAPHICS	\$10,000	\$0.20	SERIAL, PARRALEL, VIDEO
PEN PLOTTERS	LINE DRAWINGS	\$ 5,300	\$0.06	SERIAL
FILM CAMERA	GOOD QUALITY	\$16,000	\$6.00	RS-170 VIDEO
FILM RECORDERS	HIGHEST QUALITY	\$30,000	\$6.00	IEEE488 PARALLEL SERIAL
LASER COPIER	PLAIN PAPER	\$31,000	\$0.06	PARALLEL
INK-JET PLOTTER	HIGH QUALITY	\$ 6,000	\$0.10	RS-232 SERIAL
ELECTROSTATIC PLOTTER	HIGH SPEED	\$ 9,000	\$0.04	PARALLEL

TABLE 5-1 Typical hardware and copy costs for currently available printers and plotters.

	IMAPRO QCR-D DIGITAL COLOUR IMAGE RECORDER	XEROX 6500 CCP INK-JET PLOTTER	PRINTACOLOUR IS 8001 COLOUR PLOTTING SYSTEM	APPLICON INK-JET PLOTTER	VERSATEC ECP42 ELECTROSTATIC COLOUR PRINTER/PLOTTER
TECHNOLOGY:	HIGH RESOLUTION CRT COLOUR FILTERING FILM RECORDING	LASER WRITING XEROGRAPHIC PRINTER	DROP-ON-DEMAND INK-JET	CONTINUOUS INK-JET COATED PAPER LIQUID TONER	ELECTROSTATIC CHARGE
RESOLUTION:	4096 COLOUR PIXELS	100 DOTS/INCH	100 DOTS/INCH	125 DOTS/INCH	200/DOTS/INCH
COLOURS:	RED,BLUE,GREEN,WHITE (16 MILLION COMBINATIONS)	CYAN,MAGENTA,YELLOW	CYAN,MAGENTA,YELLOW (7 COMBINATIONS)	CYAN,MAGENTA,YELLOW	CYAN,MAGENTA,YELLOW & BLACK (512 COMBINATIONS)
SPEED:	20 TO 240 SECONDS (DATA DEPENDANT)	180 SECONDS (3 COPIES/MINUTE)	120 SECONDS/PAGE (BIDIRECTIONAL)	8 MINUTES/ PLOT	8 MINUTES/E-SIZE PLOT (34 X 44 INCH)
IMAGE SIZE:	24 X 36 MM 4 X 5 INCH 8 X 10 INCH	8.5 X 11.0 INCH	11 X 15.7 INCH (FAN-FOLD)	22 X 34 INCH (D-SIZE)	42 INCH X 500 FEET
QUALITY:	VERY HIGH	MEDIUM	MEDIUM	VERY HIGH	VERY HIGH
VERSATILITY:	LINE,SOLID AREA 256 GREY LEVELS	LINE,SOLID AREA HALF TONE	PRINT & PLOT	LINE,SOLID AREA HALF TONE	LINE SOLID AREA HALF TONE
COST (US \$):	\$25,000	\$31,000	\$5,700	\$55,000	\$98,000

	TRILOG C-100 IMPACT PRINTER	HP7220C PEN PLOTTER	HP 7580A PEN PLOTTER	DUNN 630 SERIES FILM CAMERAS	GEO SPACE 6400 FILM PLOTTER
TECHNOLOGY:	DOT MATRIX IMPACT PRINTER	MECHANICAL, FIBER TIP PENS	MECHANICAL PENS	HIGH RESOLUTION CRT COLOUR FILTERING FILM RECORDING	CRT SCANNING FILM
RESOLUTION:	100 DOTS PER INCH	.001 INCH	.001 INCH	1200 LINES/FRAME	192 LINES / INCH
COLOURS:	CYAN, MAGENTA, YELLOW	8 PENS	8 PENS	RED, GREEN,BLUE	CYAN, MAGENTA, YELLOW
SPEED:	PLOT: 3.75 MIN/PAGE PRINT: 150 LINES/MIN	SLOW (14 IN/SEC)	SLOW (24 IN/SEC)	1 MIN	2.5 MIN
IMAGE SIZE:	11 X 13 INCH	11 X 17 INCH (A3)	24 X 46 INCH (O SIZE)	8 X 10 INCH	42 X 60 INCH
QUALITY:	MEDIUM	HIGH LINE QUALITY	HIGH LINE QUALITY	HIGH QUALITY	VERY HIGH QUALITY
VERSATILITY:	PRINT & PLOT	LIMITED	LIMITED	LINE, SOLID AREA, CONTINUOUS TONE	LINE, SOLID AREA, CONTINUOUS TONE
COST (US \$):	\$11,800	\$5,300	\$15,400	\$16,000	\$63,000

TABLE 5-2 Price and performance comparison of a selection of recorders and printers.



P
91
C655
T47
1983

DATE DUE
DATE DE RETOUR

20 NOV 1984
MAR - 5 1990
MAY - 7 1990

