RCSL No: 44-RT2054

Edition: March 1983

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Title:

TF160 Loadable Character Font Reference Manual

RCSL No 42-i 2164

A/S REGNECENTRALEN
af 1979

Keywords: RC855, TF160, CRT505, Loadable Character Font, Reference Manual.

Abstract: The manual describes a terminal feature, TF160, which enables the user to define and load a special character set in addition to the standard RC855 character set. A general description of the display module and the organization of character fonts is included. Furthermore, the utilization of the facilities from a program running under CP/M control is explained.

(26 printed pages)

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Printed by A/S Regnecentralen af 1979, Copenhagen

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1. INTRODUCTION 1.

The TF160 loadable character font makes it possible for the user to define his own special character set (e.g. a semigraphic character set) extending the standard RC855 character set. The user-defined character set may consist of up to 256 different characters which can be displayed anywhere on the screen.

A general description of the display module and the organization of the character fonts can be found in chapter 2.

The RC855 CP/M 2.2 operating system (release 1.3 or newer) fully supports load of and access to the user-definable character set. Chapter 3 explains how to utilize these facilities from a program running under CP/M control.

2. FUNCTIONAL DESCRIPTION OF THE DISPLAY MODULE 2.

2.1 General Description 2.1

To create the visual impression of a picture on the CRT (Catode Ray Tube = electron beam tube) screen, the screen contents must be output to the CRT with a repetition rate of more than 50 times per second.

As the screen contains 288000 "pixels" (i.e. dots with mutually independent light intensity), the CRT must constantly be fed with an information stream with an average speed of 60 x 288000 x 3 = 51.5 Mbits/sec. (60 frames/second, 288000 pixels/frame, 8 Intensity levels/pixel). Clearly the CPU cannot supply that directly, so this is the task of the display module.

The electron beam sweeps the screen in horizontal lines covering the screen as shown in fig. 1.

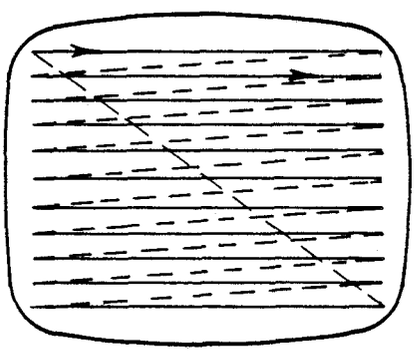


Figure 1: Scan pattern on the CRT screen.

Wherever the beam hits the screen, the phosphor will transform the energy of the electrons being decellerated from a high velocity into light, the intensity of which depends on the intensity (current) of the beam.

So modulating the beam current in dependence of the momentary position of the impact gives control of the distribution of light over the screen.

The pixels are hence organized in 400 lines grouped in 25 rows with 16 lines each.

The lines consist of 720 pixels each, organized in 80 columns with 9 pixels each.

Each intersection of a row and a column makes out one character position hence the screen can display 25 rows with 80 characters in each.

Each character position has 16 lines with 9 pixels each. Referring to the block diagram (fig. 2), the display module has some memories for refreshing the screen.

The screen refresh memory has an item (two bytes) for each character position, selecting which character is to be displayed at that position, and how the character is displayed (green on black, black on green, blinking or white (ultra bright) on black).

The information for a certain character position is (controlled by the CRT address sequencer) coming out of the screen refresh memory every time the e-beam is coming into this character position. This happens 16 times for each character position for each screen refresh due to the way in which the CRT is swept.

11 bits are used to select two characters to be superimposed eachother in this position. 9 bits select one character (out of 512), 2 bits select the other character called the "shadow".

5 bits are used to select one of 32 eight bit attributes explained in detail in section 2.5.

The character fonts are addressed by the 9 + 2 bits from the screen refresh memory plus a 4 bit number from the CRT address sequencer indicating which of the 16 lines within the character is to be displayed.

The output of the character fonts are two 9 bit words superimposed eachother (logically or'ed) making out the dotpattern to be displayed.

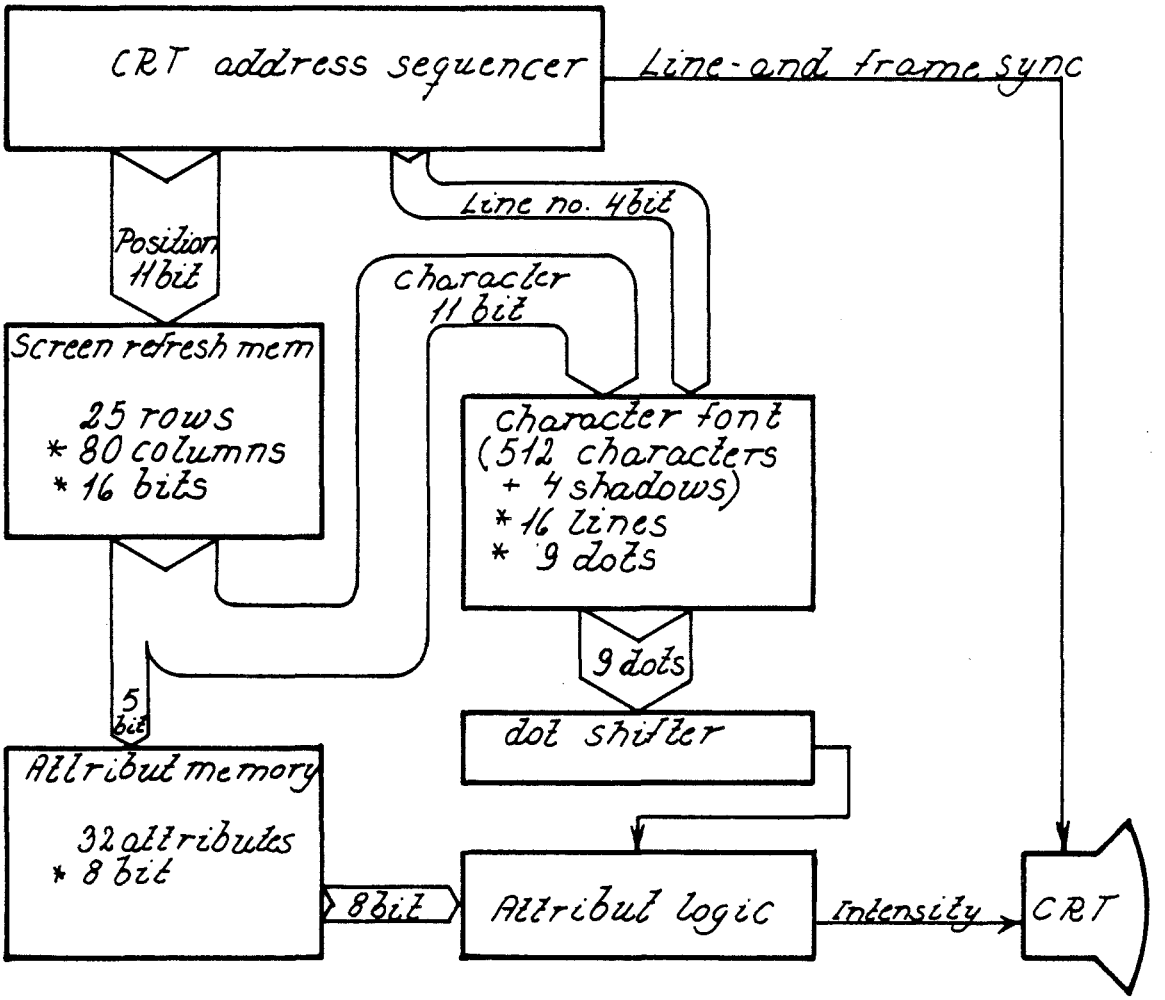


Figure 2: Blockdiagram for CRT505.

The 9 bits are shifted out of the shifter one by one, and used in the attribute logic to select background (0) or foreground (1) to be displayed in this pixel.

The following describes the components of the Display module.

Name	Use
CRT Address sequencer	Initialize display constants, cursor control
Screen refresh Memory	Memory for characters and attributes for every position on the display 2048 x 16. 2000 x 16 used for 2000 display positions
Shadow font RAM	Memory for a shadow pattern which is displayd together with the character pattern. 4 x 16 x 9 used for 4 shadow patterns
Character font ROM	Memory for 128 or 256 pre-loaded character patterns 128 x 16 x 9 or 256 x 16 x 9
Character font RAM	Memory for 256 loadable character patterns 256 x 16 x 9
Attribute RAM	Memory which converts the 5 attribute bits to the possible light effects

2.2 CRT Address Sequencer 2.2

The task of the CRT address sequencer is repeatedly to generate addresses for reading the screen refresh memory and the character fonts. It also generates the necessary line sync and frame sync signals to the CRT.

2.3 Screen Refresh Memory 2.3

The screen refresh memory consists of 4096 bytes of which only the 4000 bytes are accessed by the CRT address sequencer.

The refresh memory is maintained as a copy of the CPU work memory with addresses F000H to FFFFH. This identity is maintained as follows: whenever the CPU or the DMA writes into a location in the mentioned area, the same data is written into the corresponding location of the refresh memory.

Each pair of addresses in the refresh memory corresponds to a character position on the screen.

The bytepair is used as follows:

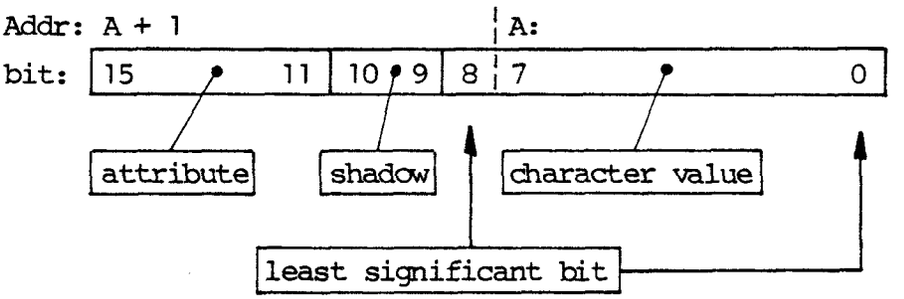


Figure 3: Refresh memory format.

2.4 Character Font 2.4

The character font converts character value to dotpattern, i.e. defines the "look" of the character with the given value.

A character consists of 16 lines each containing 9 pixels.

The character font consists of:

1) a read only font containing up to 256 characters,
2) a loadable font containing up to 256 characters and
3) a loadable "shadow"-font containing up to 4 "shadows" to be superimposed (logically or'ed to) the displayed character.

The character value Ch(0:10) from the refresh memory is used together with the correct line number from the CRT address sequencer to address a line of a character and the same line of a shadow. The 16 output bits from the two are or'ed in 16 or-gates, and the result is loaded into the shift register to be shifted bit by bit into the attribute logic at a rate of 32 Mbits/sec.

Ch(0:8) selects the character, if Ch(8) is zero, the read-only font is addressed, else the loadable font is addressed.

Ch(9:10) selects the shadow.

All three fonts may be accessed by the CPU, by means of DMA transfers to or from the CPU memory. The shadow font cannot be read from the CPU.

When a font is transferred, the characters (or shadows) are transferred in the order of increasing value (zero first corresponding to lowest memory address), each character occupying 32 bytes in the CPU memory.

		first byte								second byte								
		bit	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
line	byte																		byte
0	0		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	1
1	2		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	3
2	4		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	5
3	6		.	*	.	.	.	.	.	*	x	x	x	x	x	x	x	x	7
4	8		.	*	.	.	.	.	.	*	x	x	x	x	x	x	x	x	9
5	10		.	*	*	.	.	.	.	*	x	x	x	x	x	x	x	x	11
6	12		.	*	.	*	.	.	.	*	x	x	x	x	x	x	x	x	13
7	14		.	*	.	.	*	.	.	*	x	x	x	x	x	x	x	x	15
8	16		.	*	.	.	.	*	.	*	x	x	x	x	x	x	x	x	17
9	18		.	*	.	.	.	.	*	*	x	x	x	x	x	x	x	x	19
10	20		.	*	.	.	.	.	.	*	x	x	x	x	x	x	x	x	21
11	22		.	*	.	.	.	.	.	*	x	x	x	x	x	x	x	x	23
12	24		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	25
13	26		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	27
14	28		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	29
15	30		.	.	.	.	.	.	.	.	x	x	x	x	x	x	x	x	31

. = logical 0 (dot off)

* = logical 1 (dot on)

x = don't care

Figure 4: A possible design of the capital letter N.

Fig. 4 shows the correlation between the character image in the CPU memory and the representation on the screen. Second and first byte refer to the location in the CPU memory. The dots are displayed from left to right.

The shadow font is intended for underlining or other marking of character positions.

To be able to disable "shadowing", you will have to load one of the four shadows with zeroes.

2.5 Attribute Memory 2.5

The attribute memory may be loaded with 32 different combinations of the attribute bits Att(0:7). The five most significant bits Ch(11:15) from the screen refresh memory are used to select one of the 32 attribute combinations to control the display of the character.

The 32 combinations are loaded from the CPU memory by means of the DMA in the same order, in which they are organized in the attribute memory, i.e. corresponding to increasing value of ch(11:15).

Apart from selecting combinations, the most significant bit from the refresh memory Ch(15) also selects the blink frequency of the character. This has no effect, if Att(0:7) do not specify blink. If Ch(15) = 0, the frequency is 6 blinks/sec. otherwise it is 3 blinks/sec.

The attributes Att(0:7) are used to control the display in the two modes specified in subsections 2.5.1 and 2.5.2.

2.5.1 Black & White 2.5.1

This mode is selected when Att(4:7) = 0.
In the B&W mode Att(0:3) have the following meaning:

Att(0): High intensity
Att(1): Non display
Att(2): Reverse
Att(3): Blink

"High intensity" augments the intensity of the e-beam, when on.

"Non display" hides the character in the background, i.e. the character is invisible, unless blink is on.

"Reverse" reverses dots and background, i.e. dots become black and the background gets the selected intensity.

"Blink" has no effect if none of the other attributes are on.

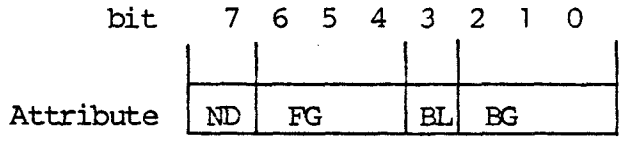
If "Blink" is on together with one of the other attributes alone or with "High intensity" and "Reverse", the character will alternatingly be displayed with and without these attributes.

If "Blink" is on together with "Non display" and one or both of the other attributes, the display is alternatingly black and showing the character without the "Non display".

In the cursor position an extra blinking reversal is active. This blink frequency is independent of the "attribute blink", and the blink is out of phase (unpredictable how much) with the "attribute blink".

2.5.2 Intensity

In Intensity mode the attribute byte is divided into four fields:



Att(7): Non Display
Hides the character in the background when on

Att(4:6): ForeGround intensity select
values 1 to 7 are valid, selects the intensity of the character dots

Att(3): BLink
when on, the character is alternatingly displayed and non displayed

Att(0:2): BackGround intensity select
values 0 to 7 are valid

The following table gives the correspondence between the values of the intensity select fields and the intensity displayed.

Intensity select	intensity
0	black
1	very low
2	low
3	reduced
4	normal
5	increased
6	high
7	very high.

3. USING THE USER-DEFINABLE CHARACTER SET FROM CP/M 3.

3.1 Loading the User-Defined Character Set 3.1

A special BIOS procedure (called SOFTCHAR) has been defined in order to allow DMA-transfers between the CPU memory and the display-module memory. The procedure handles transfers to/from the character font RAM, to the attribute RAM, to the shadow font RAM and from the character font ROM.

The entry to SOFTCHAR can be found at BIOS + 62h (the BIOS is located at addr. 0DA00h in a 56k CP/M system i.e. the entry to SOFTCHAR is at addr. 0DA62h). When SOFTCHAR is called, the following parameters must be specified in the appropriate registers:

A = op-code (0-4)
BC = number of bytes to transfer
HL = addr. of first byte in CPU memory to transfer to/from.

The op-code may take the following values:

op-code	transfer from	transfer to
0	CPU memory	character font RAM
1	character font RAM	CPU memory
2	CPU memory	attribute RAM
3	character font ROM	CPU memory
4	CPU memory	shadow font RAM

Due to the design of the DMA-controller chip it is mandatory to start a transfer beginning with an even address i.e. HL must always be even. (A few DMA-controllers tend to lock-up if the DMA-transfer begins from an odd address).

Example:

```
BIOS        EQU  0DA00h        ; start of BIOS in a 56 k
                               ; system
SOFTCAR     EQU  BIOS+62h      ; entry to SOFTCHAR
                               ;
LOAD_FONT:  LD   A,0           ; op-code = transfer to
                               ; character font RAM
            LD   BC,128*32     ; 128 characters
            LD   HL,CHAR_DEF   ; addr of character
                               ; definition area
            CALL SOFTCHAR      ; load character set
            RET
```

3.2 Accessing the User-Defined Characters 3.2

The character font RAM which physically holds 256 characters is logically divided into 2 user-defined character sets, each holding 128 characters. In order to access these 2 character sets the normal display-handling has been split into 3 display-modes, where mode 0 (the default mode) corresponds to the standard RC855 CP/M 2.2 display-handling (see [ref. 1], app. B). In display-mode 1 and 2 the set-attribute characters are replaced by one of the user defined character sets. This has no effect on the current attribute which will apply until the display-mode is set back to 0 and a reset attribute character is sent to the display-driver.

The characters are interpreted by the display-driver in the 3 modes as follows:

character	mode 0	mode 1	mode 2
255	set	user-defined	user-defined
	attributes	character	character
128		set 1	set 2
127	standard	standard	standard
	character	character	character
32	set	set	set
31	control	control	control
0	characters	characters	characters

The display-mode can be changed by sending one of the following control-characters to the CONOUT-procedure:

character	operation
3	set display-mode 0
12	reset console display, set mode 0
14	set display-mode 1
15	set display-mode 2

The display-driver will ignore the control-characters 14 and 15 unless a transfer to the character font RAM (using SOFTCHAR) has been performed at least once since the last cold-boot.

If you wish to use the user-defined character sets and the set-attribute characters simultaneously, you will have to switch back to mode 0 whenever the current attribute is to be changed. This is illustrated in the following example.

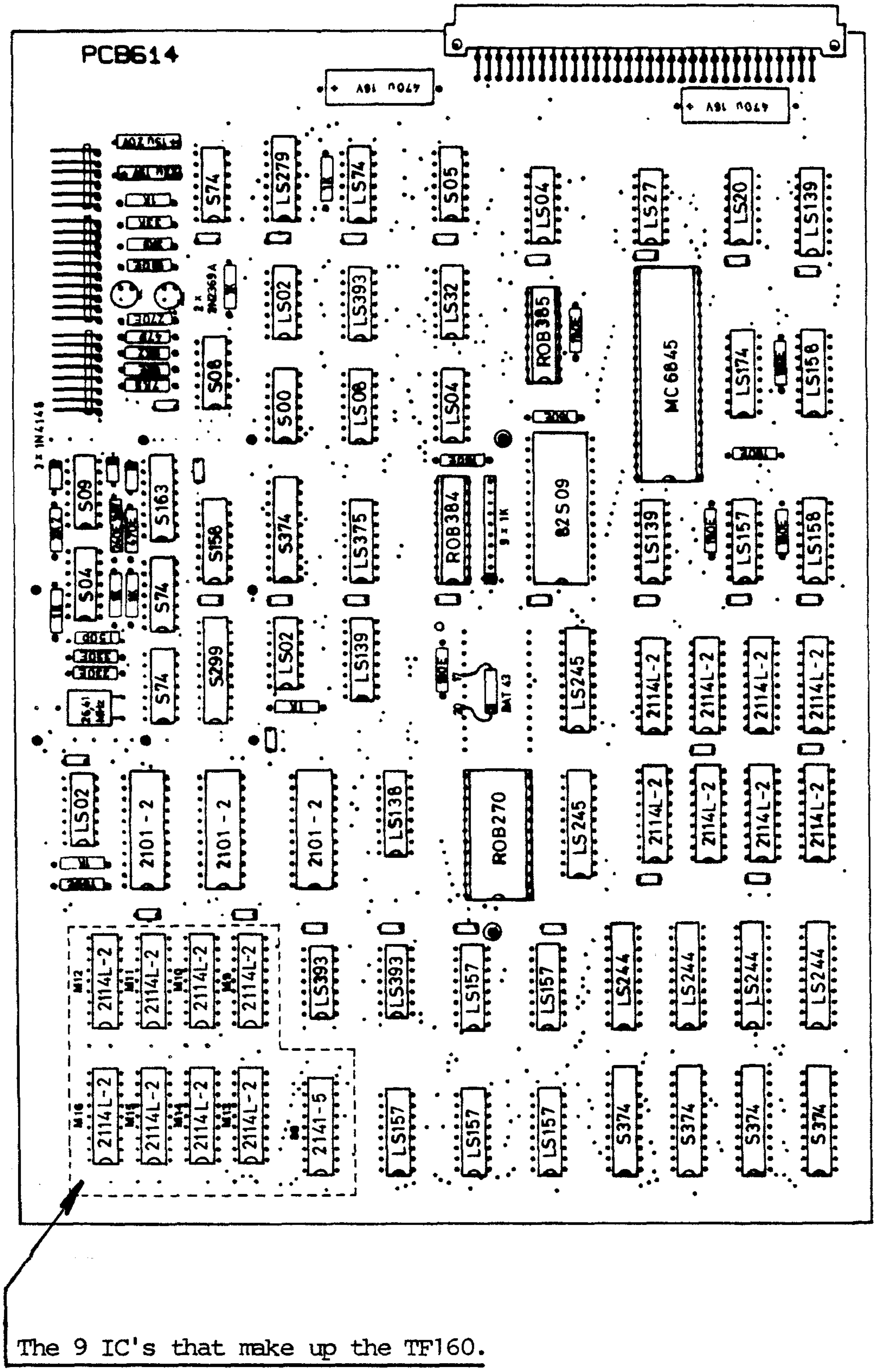
Example:

```
                                    ; display the first
                                    ; user-defined character-
                                    ; set in inverse video
DISP_INV:  LD   C,128+16            ; set inverse vido
           CALL CONOUT              ; attribute
           LD   C,14                ; set display-mode 1
           CALL CONOUT              ;
           LD   B,128               ; loop counter
           LD   C,128               ; first character to
                                    ; display
LOOP:      CALL CONOUT              ;
           INC  C                   ; next character
           DJNZ LOOP                ; repeat until count = 0
           LD   C,3                 ; set display mode 0
           CALL CONOUT              ;
           LD   C,128               ; reset attribute
           CALL CONOUT              ;
           RET                      ;
```

A. REFERENCES A.

[1] RCSL No 42-i2185:
RC855 Work Station, User's Guide

B. CARD ASSEMBLY OF CRT505 WITH TF160 INSTALLED B.



The 9 IC's that make up the TF160.

C. INDEX C.

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