CHARACTER GENERATION USING DOT MATRIX METHODS

INTRODUCTION

Dot matrix systems are used in many areas of commerce and industry as a method of character display. Two notable ones being computer V.D.U.'s and the teletext information service.

This handout deals with the basic principles of dot matrix encoding, explains how a typical character generator using this system works, and shows how the legibility of the displayed characters can be improved by using a technique known as character rounding.

1.1 DOT MATRIX ENCODING

In these systems each character is defined by the presence or absence of dots contained within an array called a 'dot matrix'. Typical array sizes are 5 x 7, 8 x 8, 5 x 9, and 7 x 9, the number signifying the number of columns and rows in the array respectively. This is shown in diagram 1.

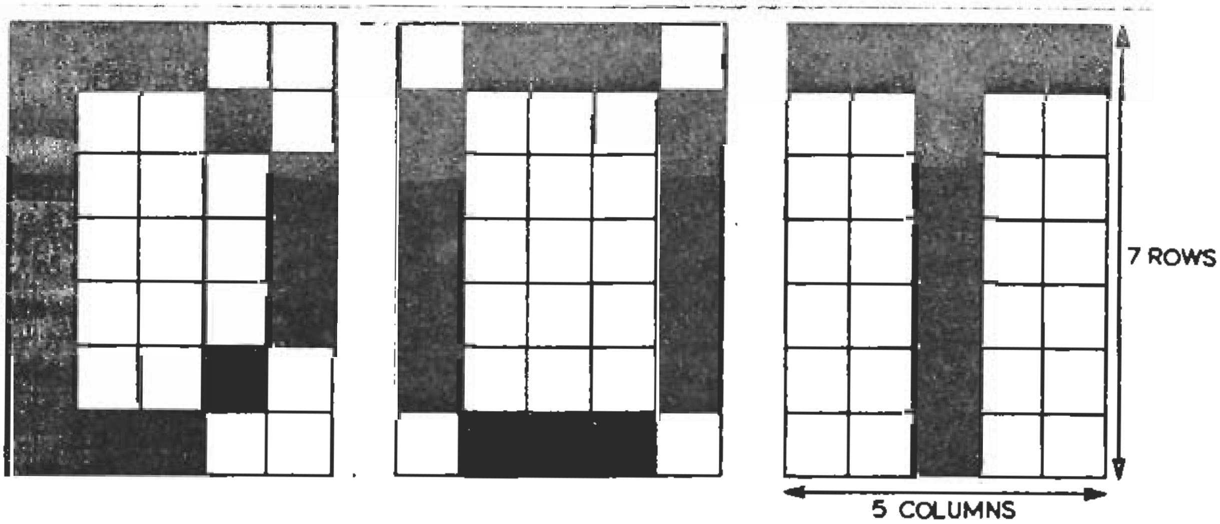


Diagram 1. 5 x 7 dot array

Each of the characters in diagram 1 can be considered as being made up of 7 rows, each row containing 5 'cells' where dots may be present or not.

CHARACTER GENERATION

The storage of information of the character make up can be accomplished by using a R.O.M. 'look-up' mechanism. The presence or absence of a particular dot in a character is defined by a '1' or a '0' in the R.O.M. respectively. In our example each character would therefore take up 35 bits of memory. Character generator R.O.M.s can be bought 'off the shelf', such as the TMS4103 which has 64 alphanumeric characters encoded in 5 x 7 arrays.

1.2 CHARACTER DISPLAY

Due to the inherent nature of the T.V. scanning system display information needs to emerge from the character generator in serial form. Each T.V. line will correspond to one row of dots in the encoded character.

This is shown in diagram 2 (we will ignore interlace for the moment).

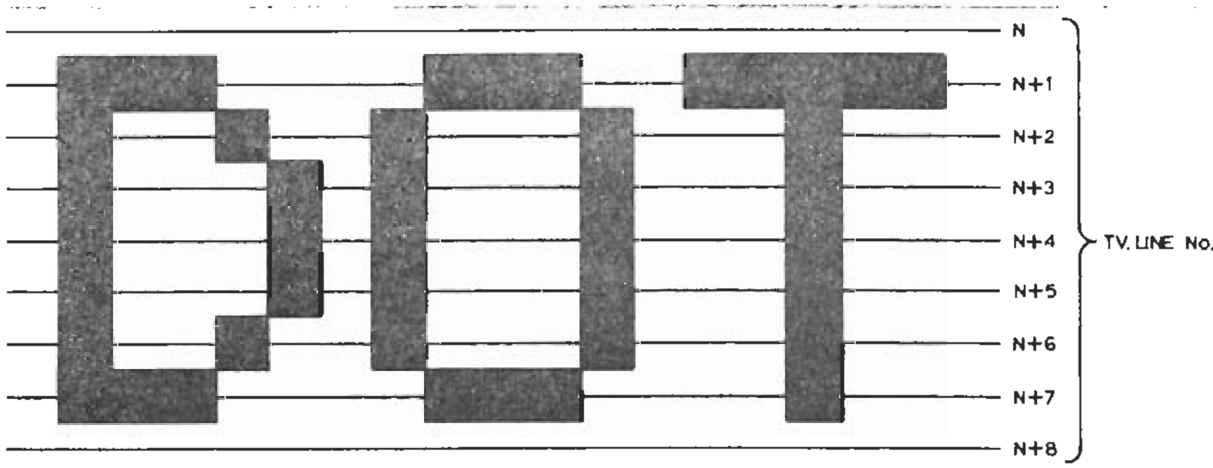


Diagram 2. Character Display Related to Scanning

It will therefore take several T.V. lines to display each character. The generator R.O.M. is organised so that each row of character information forms one 5 bit byte of display data. To access each of these bytes the R.O.M. needs to be presented with a two part address as follows:-

1. The binary code for the particular character required to be generated. This is normally the ASCII code.

2. The 3 bit binary code of the row within that character.

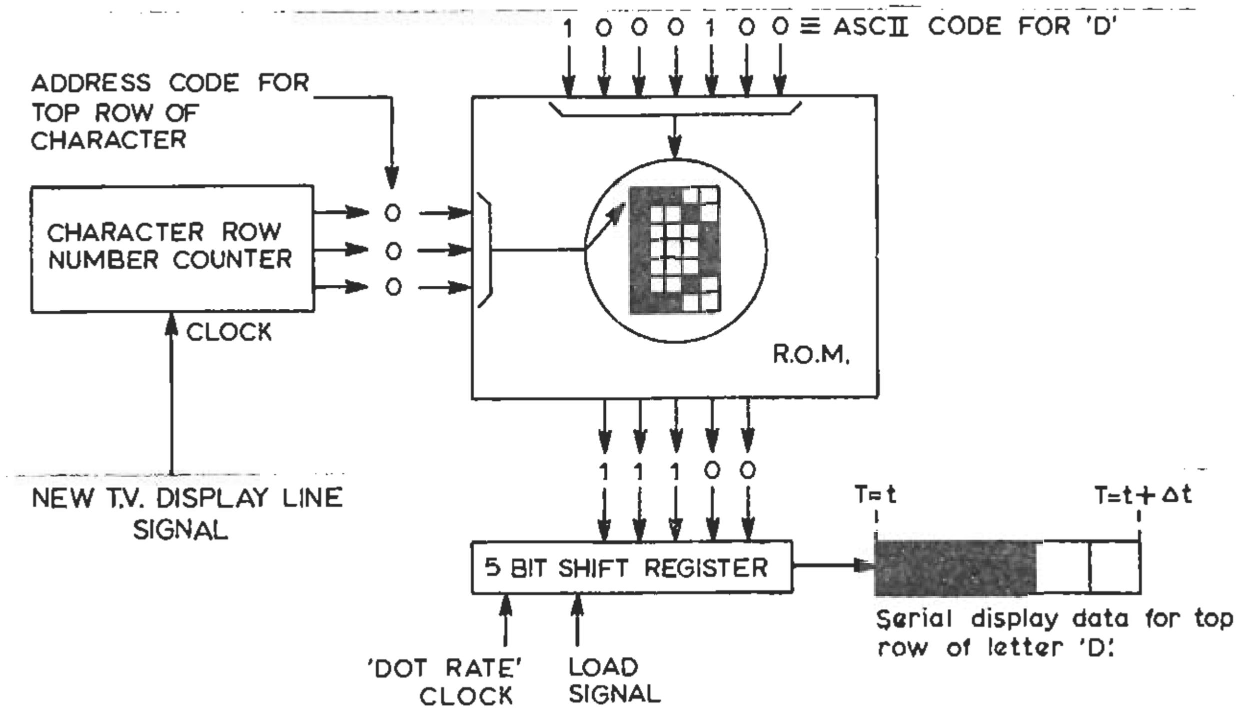


Diagram 3. Accessing the Character R.O.M.

The shift register in diagram 3 is required to serialise the character row data produced by the R.O.M. Another point to note is that the character row number counter is incremented each T.V. display line.

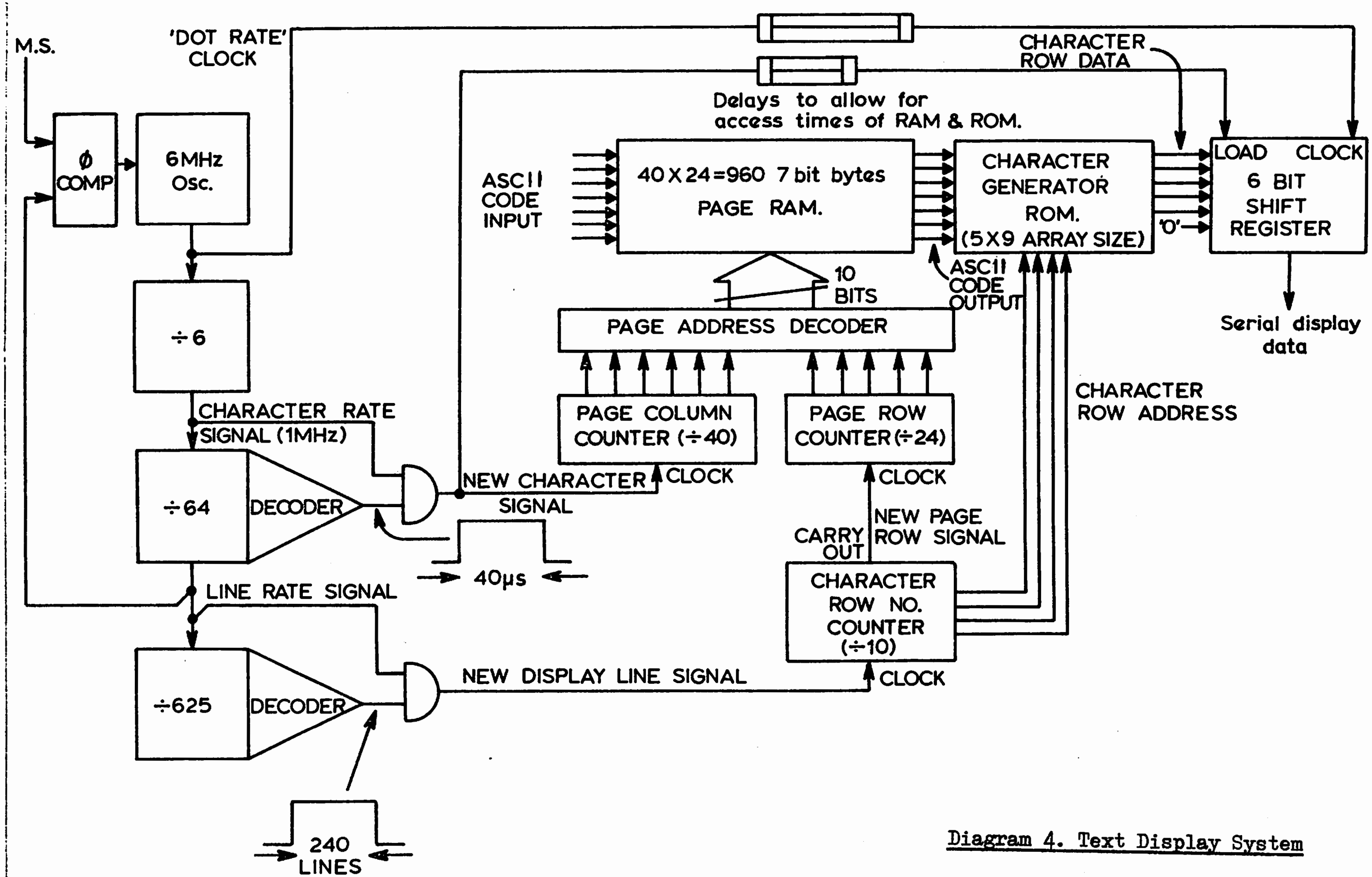


Diagram 4. Text Display System

1.3 DISPLAYING COMPLETE PAGES OF TEXT

We are now in a position to analyse a system for displaying whole screens (or pages) of text. Diagram 4 shows such a system and is similar to that used for teletext.

The character generator R.O.M. in this case has a dot matrix array size of 5 x 9 and a typical character set would be as shown below.

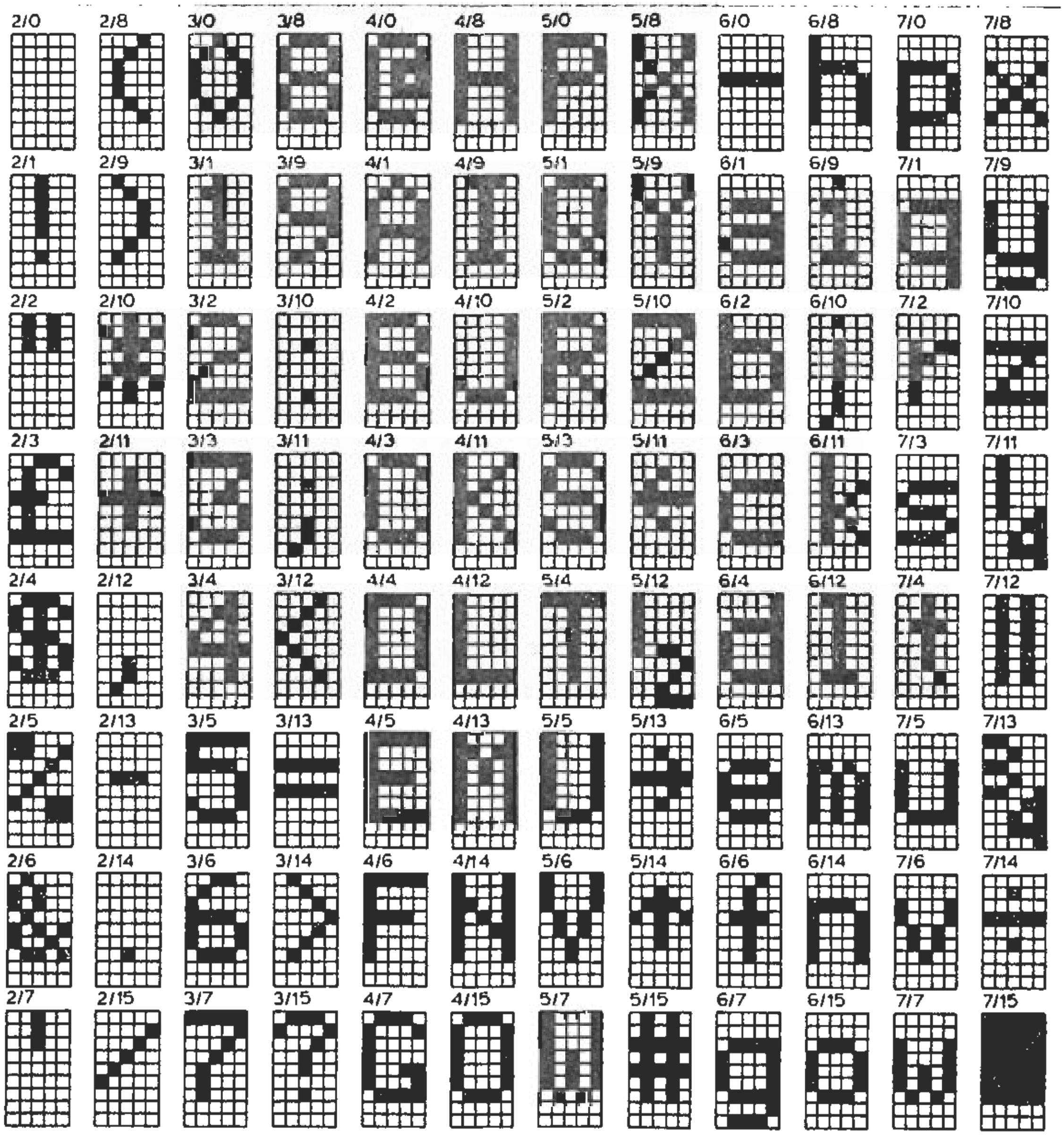


Diagram 5. Typical Character Set

CHARACTER GENERATION

Notice that the 'baseline' of the set is two cells up from the bottom of the array. this allows space for the 'decenders' in the final page of text. This is illustrated in Diagram 6.

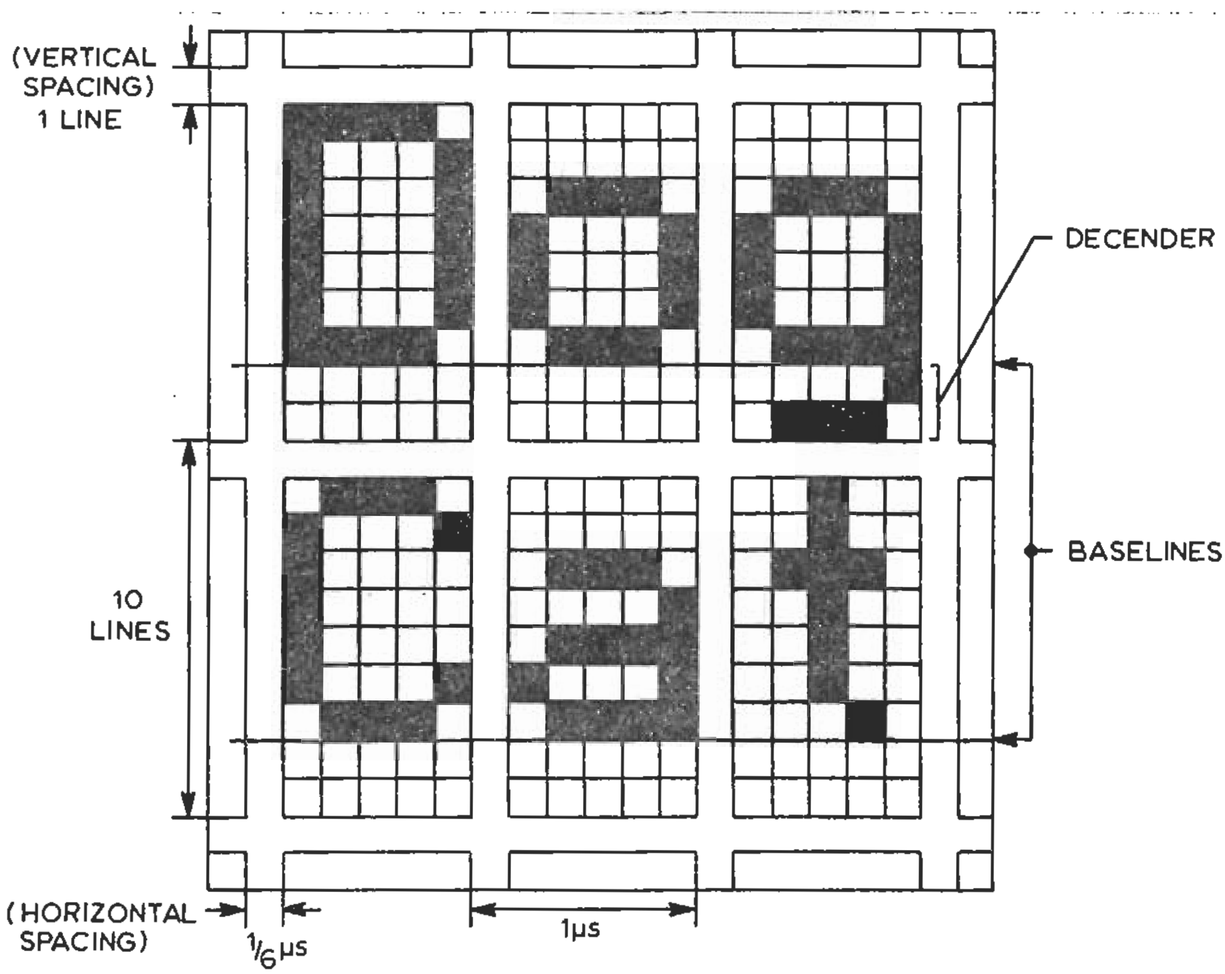


Diagram 6. Text Spacing

The display system uses a 6MHz clock and this determines the width of the dots in the characters i.e. 167ns. To prevent the characters merging into one another it is necessary that they are spaced in both a horizontal and vertical direction.

Horizontal spacing of one dot width is achieved by using a 6 bit shift register at the system output and having a logic '0' permanently connected to its end bit. Vertical spacing of one line results from using a ÷10 characater row number counter (characters only have 9 lines of data!)

CHARACTER GENERATION

This system of spacing is known as non-proportional spacing i.e. the spacing between character boxes does not vary from character to character.

The signals from the decoders on the ÷64 and ÷625 stages are required so that text is only produced within a 'safe' area on the screen i.e. within domestic cut-off. This is illustrated in diagram 7.

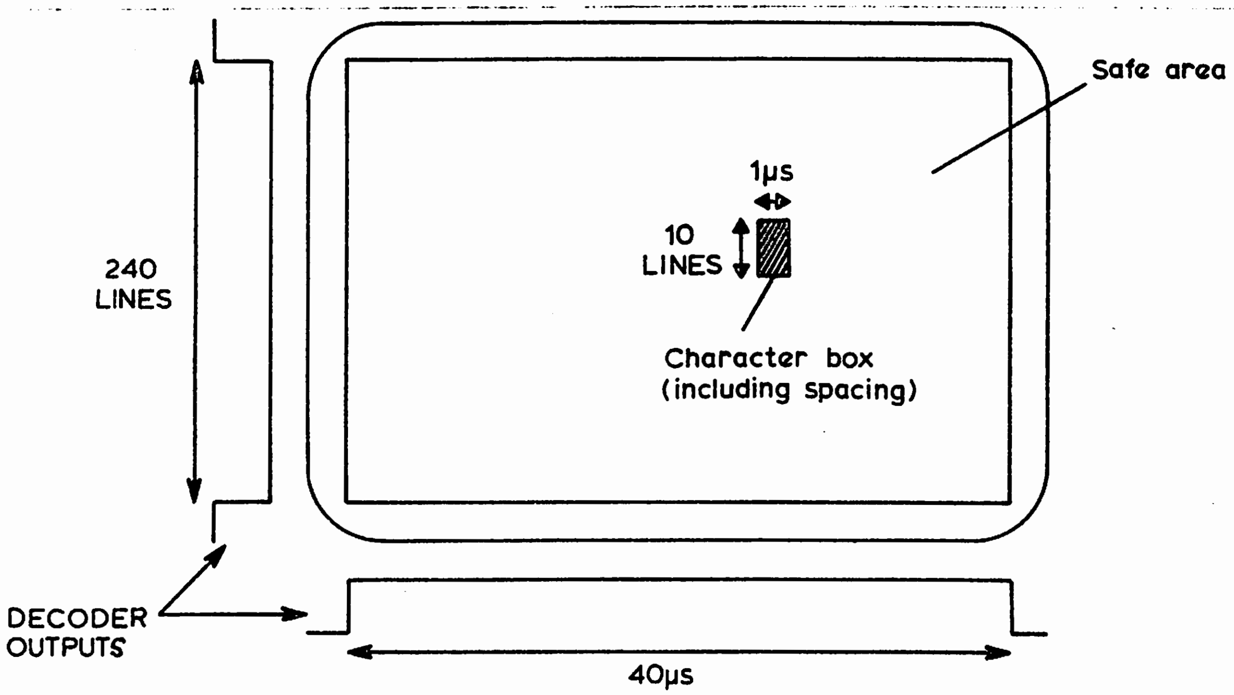


Diagram 7. Safe Area

A page can contain 24 rows of text, each row having up to 40 characters. The Page R.A.M. is thus required to store the ASCII codes (960 in all) in the correct positions, for a whole page of text.

A new page of ASCII codes can be written into the R.A.M. as required. In a Teletext system these codes would come from decoding the pulses in the lines of transmitted Teletext data. The R.A.M. can therefore be thought of as a 40 x 24 array, each array element containing either a blank code, if no character is to be displayed, or a character code if one is to be displayed at that position on the screen.

One T.V. line will contain one row of dots only, from up to 40 characters. The next row of dots of a particular character will need to emerge from the generator 64μs later and therefore appear on the screen immediately below the previous set. Thus in order to display a complete character the R.A.M. outputs its ASCII code 9 times over at 64μs intervals. This is taken care of 'automatically' by the page row counter. In this way text is built up on the screen. Diagram 8 shows most of the system waveforms.

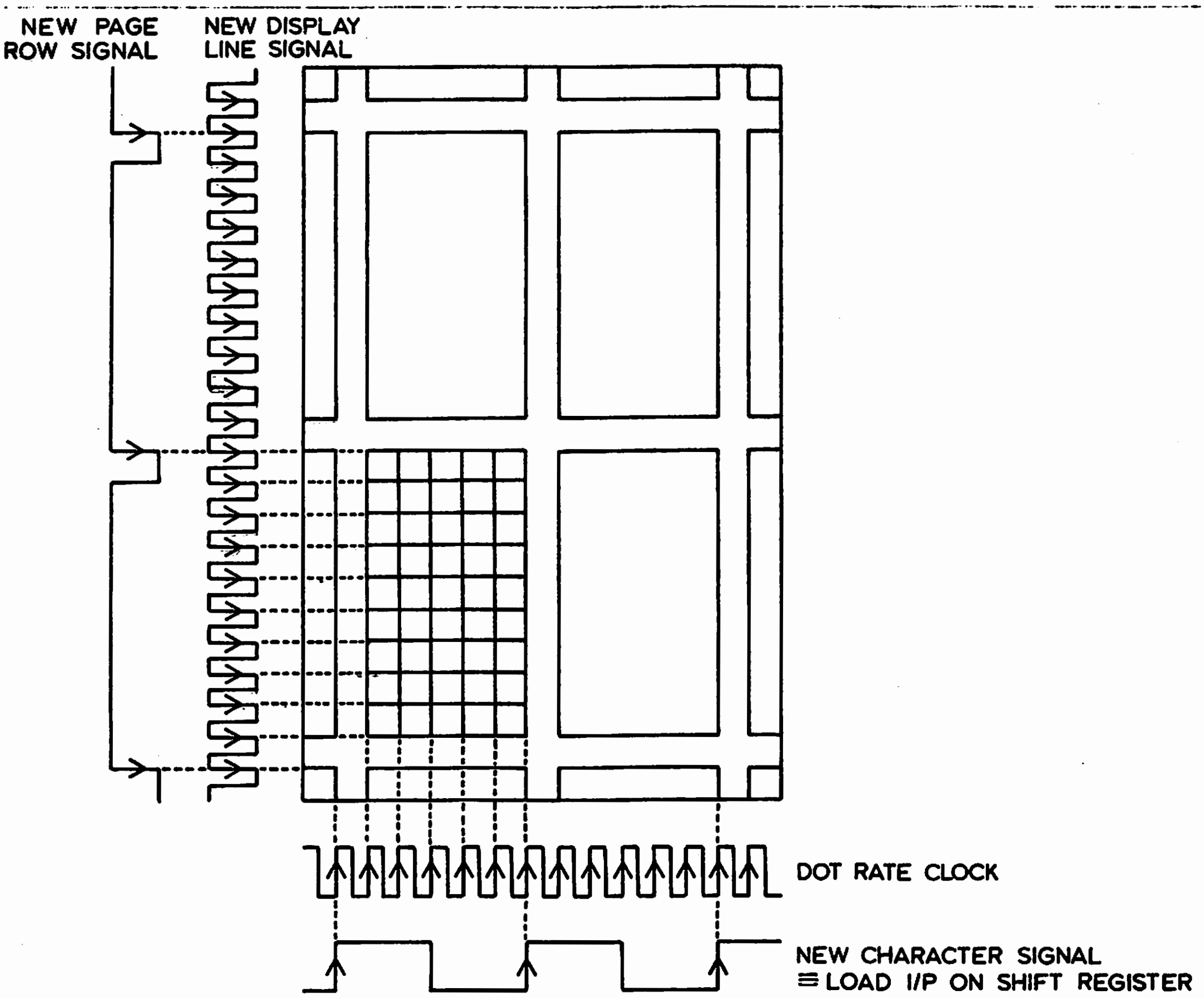


Diagram 8. System Waveforms

1.4 PROBLEMS DUE TO INTERLACE

So far we have ignored the fact that a T.V. picture is made up of two fields which are interlaced.

What effect does this have on the displayed text? If the same character information is used on both T.V. fields, pairing of line information results.

This problem can be overcome by using a technique known as 'character rounding'. Its effect is shown in diagram 9.

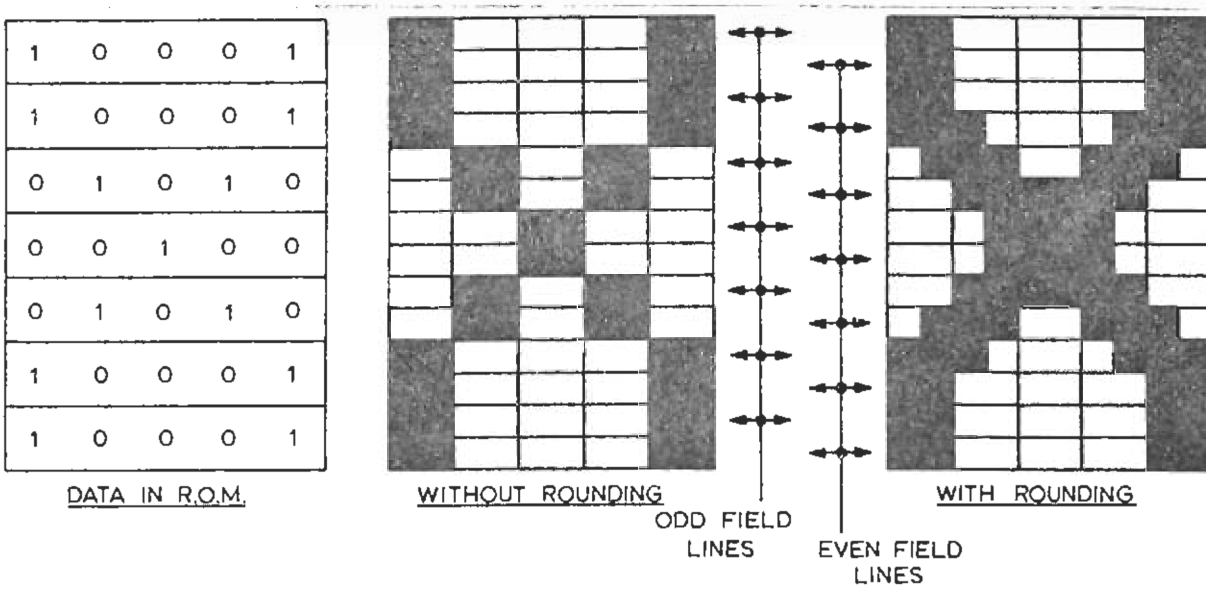


Diagram 9. Effect of Character Rounding

It can be seen that the rounding doubles both the horizontal and vertical resolution of the character, the odd and even fields now containing different information from each other. The rounding process effectively adds in 1/2 cell width dots on diagonal lines and this doubling of resolution can be achieved without a corresponding increase in character generator complexity.

2. CHARACTER ROUNDING

The basis of character rounding can be explained as follows:-

When an ODD field is being scanned the top dot in a diagonal pair is displayed unmodified. However the bottom dot has a half dot inserted before or after it. This is known as pre-rounding or post-rounding respectively. The half dot is always underneath the top dot.

A similar rule applies for EVEN fields, but in this case the top dot is rounded and the bottom one left unmodified. Diagram 10 illustrates this.

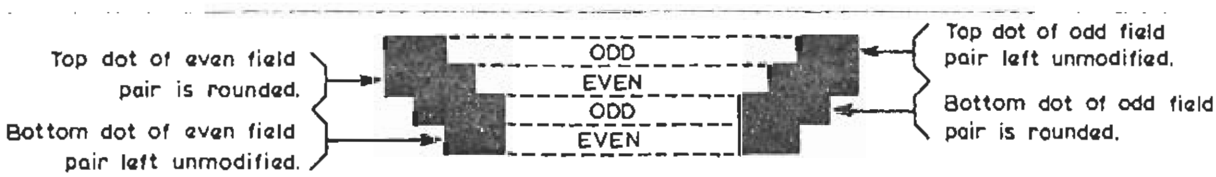


Diagram 10. Rounding in Odd and Even Fields

To determine whether or not rounding is necessary it is evident that dot information on successive pairs of lines needs to be compared. This will establish the presence of any diagonals.

A circuit which will perform rounding is shown in diagram 11 and its operation can be explained as follows:-

The character generator R.O.M. is accessed twice during each horizontal character period (1μs), and the data loaded into the display and reference shift register respectively. The R.O.M. address required to generate the reference data is obtained using the +1/-1 adder stage and selected by the multiplexer at the appropriate time.

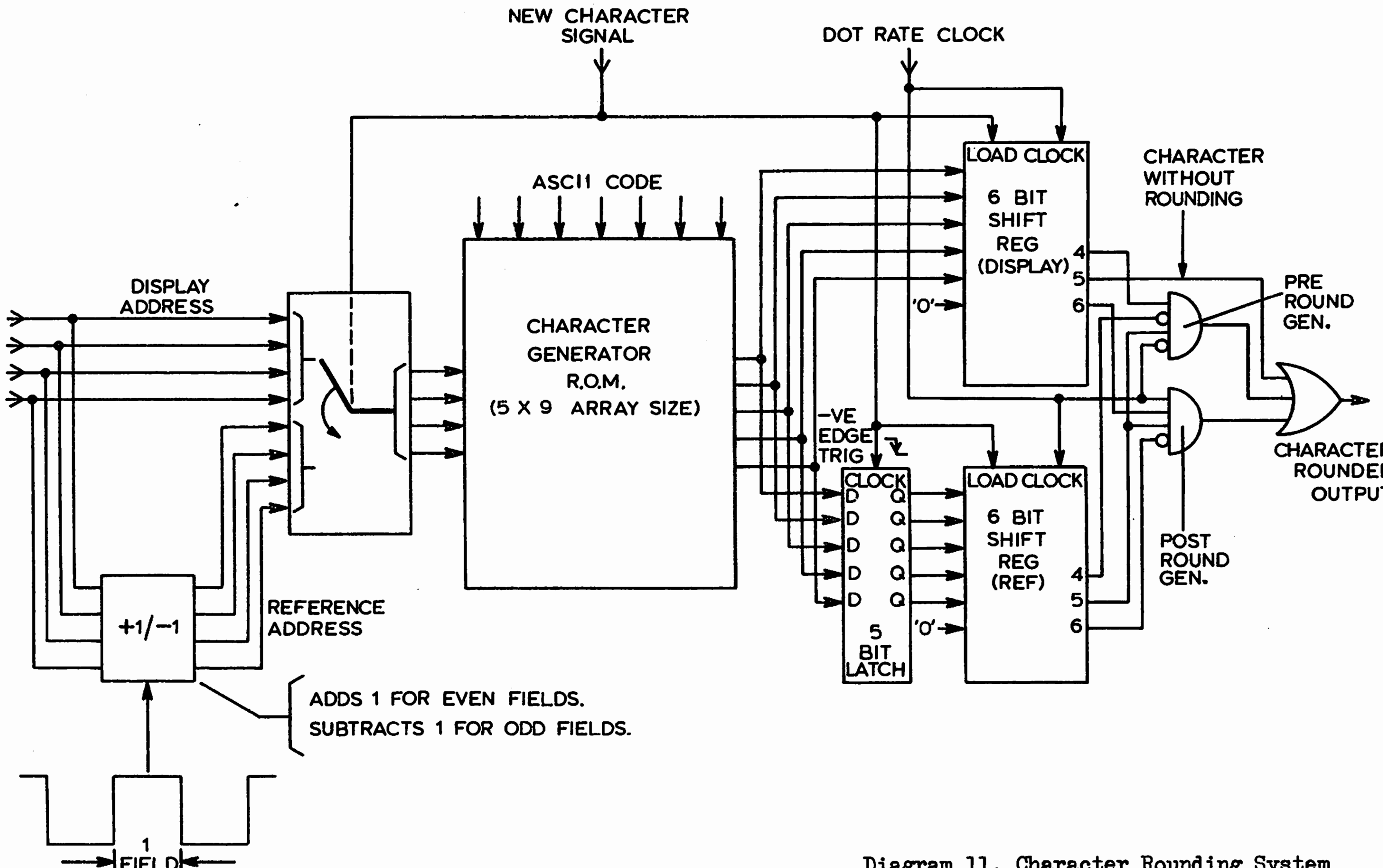


Diagram 11. Character Rounding System

The reference shift register therefore outputs character dot information which is either one line behind or one line ahead of the display shift register for odd and even fields respectively. The circuit waveform timings are shown in diagram 12.

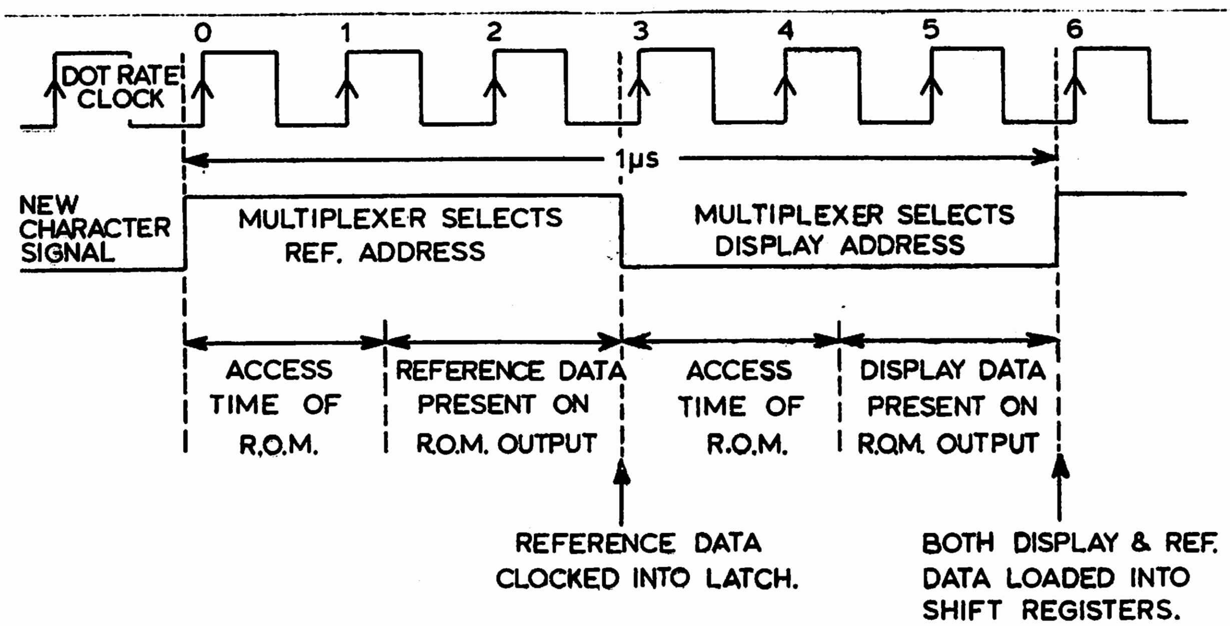


Diagram 12. Circuit Timings

The diagonal line detection and subsequent addition of pre or post rounding half dots is done by the three logic gates on the outputs of the shift registers.

CHARACTER GENERATION

The requirements for rounding can be best described by the following truth tables in diagram 13.

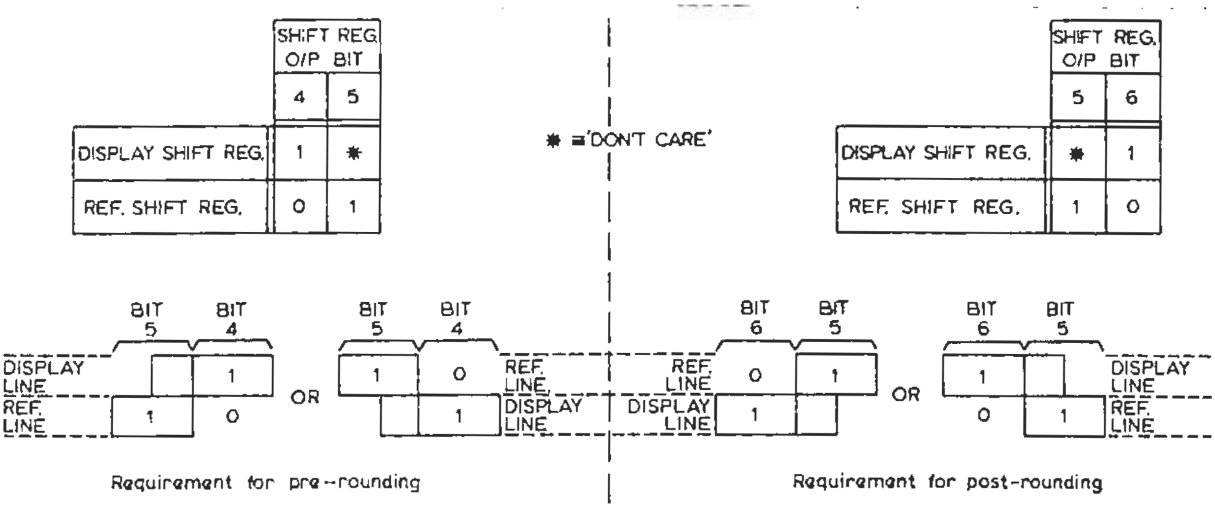
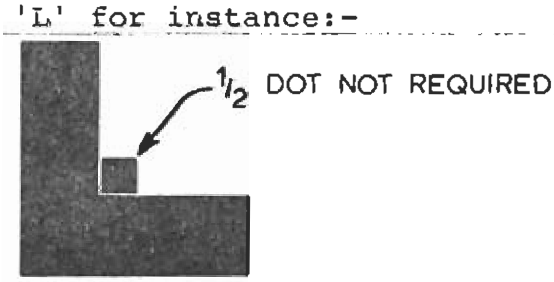


Diagram 13. Rounding Requirements

Why is it necessary to detect the absence of a dot on bits 4 and 6 of the reference register for pre and post rounding respectively?

This is to stop a half dot being inserted at the elbow of a letter 'L' for instance:-



Each of the truth tables is realised with an 'AND' gate at the outputs of the shift registers.

The half dot width pulse is obtained from gating in the dot rate clock for post-rounding, or its inverse (pre-rounding). Hence the clock forms the fourth input to the 'AND' gates.

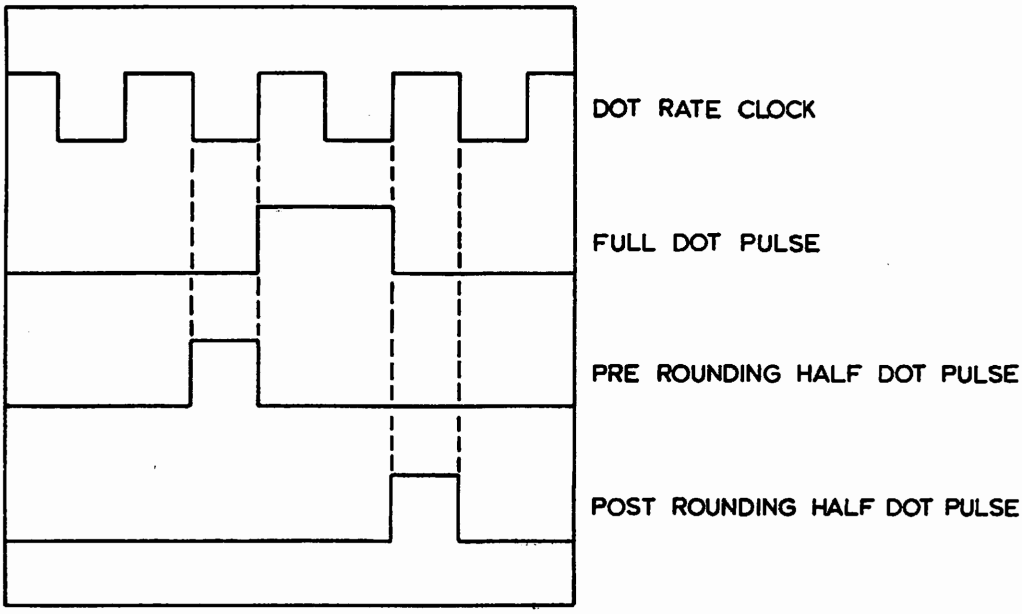


Diagram 14. Rounding Half Dot Pulses

The 'OR' gate on the output effectively 'adds in' the pre and post round pulses to the charactetr dot string.

Character Rounding Summary

We have seen how a character rounding technique has been used to double both the horizontal and vertical character resolution without a corresponding increase in the complexity of the generator. To obtain this resolution without using rounding would have required an increase in the R.O.M. size of a factor of 4. For the same character dimensions the dot rate clock would also need to be doubled in frequency.

Character generator chips are available with rounding circuitry incorporated within them. A typical example being the Mullard SAA5050 teletext chip.