Fax Standards

Group 3 Fax

CCITT Draft Documentation T.4 (1980)

- Left to right raster scan starting at top of the page.
- Each line has 1728 pel (picture elements - black or white)
- Line width : 215 mm, 3:85 lines/mm.(or 7.7 lines/mm for higher density)
- On ISO A4 Size paper. Today's fax machines scan documents many times faster and store them internally.

Transmission time: 20 ms/scan line including data, fill bits and end-of-line code (EOL) (000000000001 – 11 0's followed by 1)

Coding Methods

There are alternate run lengths of white and black pels. The first run is assumed to be white; if not, it is assumed to be 0 with code of '00110101'

$$Run\ Length = 64 \times m + t$$

64m = represented by '**M**ake-**U**p-**C**ode' (***MUC***)
t = **T**erminating **C**ode (***TC***)

Max Run length = 1728 = 64.63+27

Two separate pairs of table for (m, t) – one for white pels and the other black pel
(See Temporary files)

For example a white run of 1362=64.21+18 = 1344+18 is encoded by concatenating the code word for 1344 (011011010) and the code word for 18 (0100111). Note *MUC* and *TC* are both prefix codes. Also, the *MUC* and *TC* in white are "mutually" prefix – no *MUC* of white is a prefix of *TC* of white and vice-versa. Blacks runs are similarly encoded by the *TC* and *MUC* prefix codes. The codewords from black codes are allowed to be prefixes of codewords from the white codes and vice versa . This does not lead to any ambiguity because run colors alternate and every run starts with a white color. Although there is no black run of length 0,a *TC* code for black 0 is needed in case the runs are exact multiple of 64, that is, t = 0.

A group 3 code obeys Morse's Principles but they are not Huffman codes. Extremely long runs are very rare but when they appear they have to be coded, if Huffman is used, by a very long code. VLC subject to maximum codeword length constraint are called "**M**odified **H**uffman **C**ode" (***MH***). Codes given in the tables are easier to retrieve. The end-of-document is indicated by sending 6 consecutive EOL signals at the end of document If a sum of runs in a line due to error is less than 1728 the default is to *fill* in the rest of the line by white pels. Encoders could take the advantage of this by totally skipping a white run if it is the last run; the decoder will automatically insert the required number of white pels to make the sum 1728. If sum is more than 1728, a fatal error is noted, the partial page is outputted and the decoder proceeds to net page.

Group 4 Fax

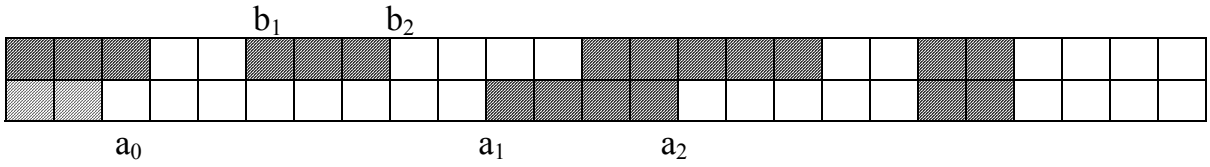
CCITT recommendation T.G (1984)

- G4 receiving apparatus is back word compatible with G3.
- G4 is two-dimensional. It exploits context between adjacent lines, and produces better compression.
- G4 is called **vertical mode** where as G3 is referred to as **horizontal mode**. To avoid propagating an error all the way down the page, the encoder selects a few lines to code using G3 horizontal code. The encoder appends a 1 to EOL (0000000000011) if the next line is in horizontal mode and appends a 0 (00000000000010) otherwise.
- Coding is done using modified *READ* (**R**elative **E**lement **A**ddress **D**esignate) algorithm.

Modified READ Algorithm

This is a recursive algorithm that updates five parameters defining correlation between two consecutive lines and code bits that are generated for each update. The top line is the reference line and the bottom line is the line being encoded. The parameters are:

a_0 - The pel at the beginning of the run about to be encoded.
a_1 - Beginning of the next run on current line.
a_2 - The beginning of the run after a_1-run.
b_1 - Beginning of a run on the reference line located right of a_0 (but having opposite color) with same color as that of a_1.
b_2 - The beginning of the run after b_1-run



If we update the value of a_0 , the value of b_1,b_2,a_1,a_2 are automatically updated according to the definitions. The modified algorithm can be stated as follows:

Step 1 :

(i) If b_2 does not lie strictly to the left of a_1, go to **step 2**

(ii) When b_2 lies to the left of b_1, select **pass mode** and transmit code 0001, as illustrated above in the diagram.

(iii) Move a_0 to column of b_2, update b_1 and b_2 (a_1 and a_2 will remain unchanged) and repeat this step.

Step 2 :

Vertical mode: pel distance, p_d, between a_1 and b_1 is less than equal to 3.

(i) If a_1 is same column as b_1 then output '1'

(ii) If a_1 is 1 column right of b_1 then output '011'

(iii) If a_1 is 2 column right of b_1 then output '000011'

(iv) If a_1 is 3 column right of b_1 then output '0000011'

(v) If a_1 is 1 column left of b_1 then output '010'

(vi) If a_1 is 2 column left of b_1 then output '000010'

(vii) If a_1 is 3 column left of b_1 then output '0000010'

Then move a_0 to position a_1, and update the other four parameters.

Step 3:

If pel distance $p_d > 3$, switch back to horizontal mode, send an output 001+$MH(a_0,a_1)$ + MH (a_1a_2), where $MH(a_0a_1)$ is the modified Huffman code for the run a_0a_1 and similarly for run $MH(a_1a_2)$. Move a_0 to a_2 position. Return to **step 1**. There are some conventions about first and last pel.