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In this paper, I describe a digital picture transmission protocol named “Run” which has the main originalities, in one hand, to be able to be included in a text and, in the other hand, to be able to be decoded at any moment when the transmission is in progress. The transmission modes supporting, at present, this protocol are Packet (300 and 1200 bauds), PSK63F and PSK220F.
The software abling this functionality is called “Multipsk”, it is downloadable from the author WEB site: http://members.aol.com/f6cte/
At the end of this paper, are presented some snapshots of the program.

Digital SSTV: general objectives of the compression and picture transmission protocol "Run" - Version 1

1) The goal here is not to transmit the binary file of an already compressed picture but:
- to load a picture file under the form of an array of pixels,
- to compress it in the most appropriate way for radio transmissions,
- to manage its transmission and reception.

2) The transmission of a compressed picture must be done, preferably, by an error-free digital transmission mode. The "Packet" in connected mode meets this need. Hence, the transmission might be done between two Hams in connected Packet mode.
However, this protocol might be used through reliable transmission modes (as PSK63F or PSK220F) which will allow, all the same, pictures transmission (even if, due to errors, the picture may show some imperfections.

3) An SWL or a Ham listening must be able to decode the digital picture, but with a risk of errors as the poorly received data will not be repeated (in Packet), so it is necessary that:
- the line changes can be identified and define the picture compression type (colors, grey scale or black and white),
- the line numbers be transmitted.

The compression unit chosen here, is the line, which excludes a JPEG type coding (DCT transform on 8x8 pixels blocks).

4) An SWL or a Ham listening must be able to decode the picture even if the transmission has already started, which excludes coding taking into account previous transmitted data (predictive coding), apart from the data of the current line.

5) The transmission will be able to be done in colors, grey scale or black and white ("HF fax" type).

6) In colors and in grey scale, the compression may affect only very slightly the picture quality (difference between the original and the copy not distinguishable without precise exam).

In black and white, it must not have losses due to compression (copy identical to the original, this to transmit, for example, electronic diagrams).

7) The size of the transmitted picture must be situated between 8x6 and 320x256 (this last format being the one used in classical analog SSTV).

Note 1: the compression rate always refers to a picture where each pixel is coded on 24 bits (classical BMP format, "bit map 24 bits").
For example, a color picture 40x30 will be initially coded (before compression) on 28800 (40x30x24) bits.

Note 2: these objectives limit the compression method choice to simple methods. The one chosen is called "RLE" (for "Run Length Encoding") hence the name of the protocol: "Run". The obtained compression rates are interesting but modest: typically 3.5 for color pictures, 7 for grey scale ones, 25 for black and white ones, weaker on photographic pictures and better on synthetic pictures. Moreover, the smaller the picture, the weaker the compression rate, and conversely.

Detailed specifications of the compression and picture transmission protocol "Run"

I) Process for the compression and the transmission of a color picture

Notations
<W>: picture width (limited to 320 pixels) expressed by 3 figures
<H>: picture height (limited to 256 pixels) expressed by 3 figures
Y: " Y Luminance" component on 8 bits initially
Cb: "Cb Chrominance" component on 8 bits initially
Cr: "Cr Chrominance" component on 8 bits initially

Operations:

1) After having opened the BMP (or JPG, but transformed by the program in a bit map picture) format file, the first operation is to transform the pixels expressed with the 3 fundamental colors R(Red), G(Green), B(Blue) in Luminance Y and Cb / Cr Chrominances components (as in JPEG compression).

2) For each component Y, Cb and Cr, one passes from a 8 bits amplitude to a 5 bits amplitude (below 5 bits, the picture is damaged), hence for 0: "00000" and for 31: "11111".
Note: the weak picture degradation is due to the passage from 16.777.216 colors to 32.768 colors, in color mode or from 256 to 32 different greys in grey scale mode.

3) The basic unit carrying the compression being the line, this operation is repeated as many times as the number of pixels on the line.
At this level, one disposes for each line, of 3 bit strings (one by component Y, Cb and Cr) composed of amplitudes situated between 0 to 31. For a component (Y, Cb or Cr), there is as many amplitudes as pixels on the line.
Example: "1 1 1 1 1 1 1 5 5 6 4 2 2 2 2...".

4) For each of the 3 components of each line, the following RLE ("Run Length Encoding") processing is called upon.
Once it is determined the number of successive amplitudes (N) having the same value, this one is preceded by the number N and the bit 0. In the same way, the number of successive amplitudes (N) having always different values are determined and these are preceded by the number N and the bit 1.
The maximum number N corresponds to 2^L -1 (for example, "111" if L=3). The number N=0 is, of course, never used.
The length L of the number N can vary from 3 to 6 bits. Each length L is tested towards the best compression rate criteria then stored on 2 bits ("00" for 3 bits to "11" for 6 bits).
Example: "1 1 1 1 1 1 1 5 5 6 4 2 2 2 2..." is written (in decimal) after processing:
"0 7 1 0 2 5 1 2 6 4 0 4 2,
"0 7 1" being written in binary, if L=3: "000000001" and if L=4: "0011100001".

5) A line, on binary form (called "LB" afterwards), is composed of the following elements:
* the start of color line: "10000000000000000001" (19 "0"),
* the line number (between 1 and 256 on 8 bits: "00000000" for 1 and "11111111" for 256),
* the number N (2 bits),
* the Y luminance binary string,
* the Cb chrominance binary string,
* the Cr chrominance binary string.

6) It is now necessary to transmit the picture under its binary form.
Before this, the correspondent Ham or the ones listening to the picture transmission must be advised.
For this, the picture must be preceded by a prefix "Run<CHR(1)><W>x<H>C" type for a color picture ("C") of dimensions <W>x<H>, using the protocol "Run". For example, the prefix "Run320x256C" might be generated by the program.

On reception of this prefix, the program passes in "digital picture decoding" and does not decode received bits as being text.
Note: this prefix has only an informative character for Hams and SWL listening. Indeed, as by hypothesis, the decoding may start during the picture transmission, other elements must permit to find the picture characteristics:
* the start of line signals give the picture type (colors, grey scale or black and white) and allow the program to pass in "digital picture decoding",
* the total number of lines is deduced from the reception of the end of picture transmission signal,
* the line width (in pixels) is deduced from the decoding.

The rules upon this prefix are the following:

* the 3 first printable characters ("Run") are fixed. They are followed by the fixed non-printable character CHR(1). These 4 characters allow to discriminate a picture transmission from a text transmission.
Note: to give more clarity to the text and to improve the synchronization, six

spaces will precede these characters.

* they will be followed by the picture format which is composed of a number of 3 figures ("040", for example), representing the picture width (<W>), followed by the "x" sign (small "X") followed by a number of 3 figures ("030", for example), representing the picture height (<H>).
The picture width must be situated between "008" and "320". The picture height must be situated between "006" and "256",

* the following letter (compulsory) is worth "C" if is a color picture, "G" for a grey scale picture, "B" for a black and white picture.
A space is transmitted after this last letter. It is just used to this character decoding.

Note: prior to the prefix, it will be possible to send a brief description of the picture or a comment.

7) Once the prefix sent, it will be sent the binary lines (LB) from the line 1 to the last line (≤256) then twice the end of picture transmission signal with the bit "0" between both: "100000000000000000000000001" (25 "0") then "0" then "100000000000000000000000001".

Note: when receiving the picture, if none signal (start of line signal or end of picture transmission signal) has been decoded during 30 seconds, the program passes back to text reception.

The decoding will be, of course, done in the coding reverse direction, from the binary string situated between two start of line signals (see 5)) or between the last start of line signal and the end of picture transmission signal (see 7)).

II) Process for the compression and the transmission of a grey scale picture

Preliminary: the original is yet a 24 bit color picture.

It is the same process as for the picture color compression, except the following elements:

* only the Luminance (Y) string will be transmitted. When decoding, it will be considered that the chrominances (Cb et Cr) are equal to 128,
* the start of line signal in grey scale is "10000000000000000001" (18 "0"),
* The prefix will be "Run<CHR(1)><W>x<H>G" type ("Run320x256G", for example) (with six spaces before).

III) Process for the compression and the transmission of a black and white picture ("HF fax" type)

Preliminary: the original is yet a 24 bit color picture.

Operations:

1) After having opened the BMP (or JPG, but transformed by the program in a bit map picture) format file, the first operation is to transform the pixels expressed with

the 3 fundamental colors R(Red), G(Green), B(Blue) in Luminance Y and Cb / Cr Chrominances components (as in JPEG compression).

2) On the Y component, it is defined a binary level "0" is the Y level is <=127 and a binary level "1" is the Y level is >=128.
The basic unit carrying the compression being the line, this operation is repeated as many times as the number of pixels on the line. So, it will be obtain a bit string, for example: "11111100000...".

3) The following RLE ("Run Length Encoding") processing is done.
The number of successive bits (N) having the same value is determined and this one is preceded by the number N and the bit 0. In the same way, it is determined the number of successive bits (N) having always different values and these ones are preceded (in fact the first bit is sufficient) by the number N and the bit 1.
The length L of the number N can vary from 3 to 6 bits. Each length L is tested towards the best compression rate criteria then stored on 2 bits ("00" for 3 bits to "11" for 6 bits).
If it is about a string of different bits, only the first bit is coded (the other bits being obviously deduced).
The maximum number N corresponds to 2^L -1 (for example, "111" if L=3). The number N=0 is, of course, never used.
If the length of a "identical bits" string is inferior to the maximum (2^L-1), the bit following this string is not coded (as its value is obvious). The same applies for a string of different bits
Example: "1 1 1 1 1 1 1 0 1 1 1 1 0 1 0 0 1 0" is written (in decimal) after processing: "0 7 1 0 4 1 1 2 1 1 2 1", and in binary, if L=4:
"001111 001001 100101 100101"

Note: there is, due to this method, an ambiguity on the last bit position. Possibly, a black pixel may hence, appear at the end of a line. The program may, however, after consideration of several lines determines the true line length and suppresses this pixel.

4) A line, on binary form (called "LB" afterwards), is composed of the following elements:
* the start of a black and white line: "1000000000000000001" (17 "0"),
* the line number (between 1 and 256 on 8 bits: "00000000" for 1 and "11111111" for 256),
* the number N (2 bits),
* the Y luminance binary string.

5) It is now necessary to transmit the picture under its binary form.
Before this, the correspondent Ham must be warned about the picture transmission. For this, the picture must be preceded by a prefix, for example "Run320x256B" for a black and white picture ("B") of 320x256 dimensions, using the protocol "Run" (with six spaces before).

The rules about this prefix have been given previously.

6) Once the prefix sent, it will be sent the binary lines (LB) from the line 1 to the last

line (≤256) then twice the end of picture transmission signal with the bit "0" between both: "10000000000000000000000001" (25 "0") then "0" then "10000000000000000000000001".

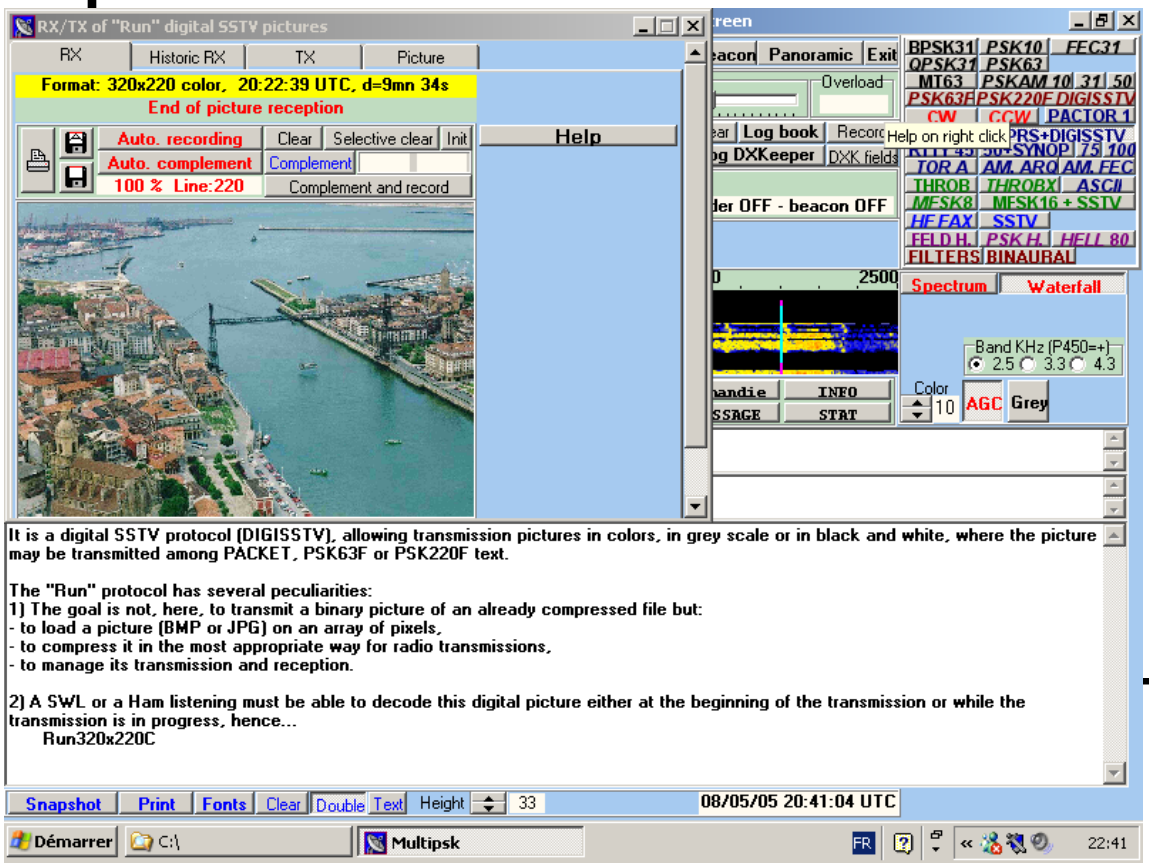
Note: when receiving the picture, if none signal (start of line signal or end of picture transmission signal) has been decoded during 30 seconds, the program passes back to text reception.

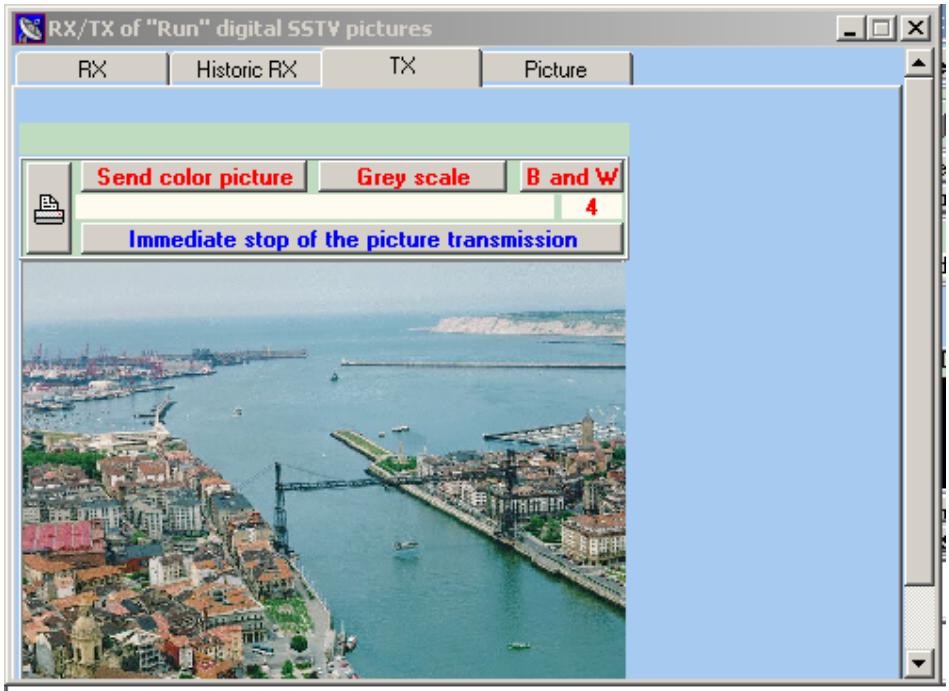
When decoding, it will be considered that the chrominances (Cb and Cr) are equal to 128.

IV) General notes

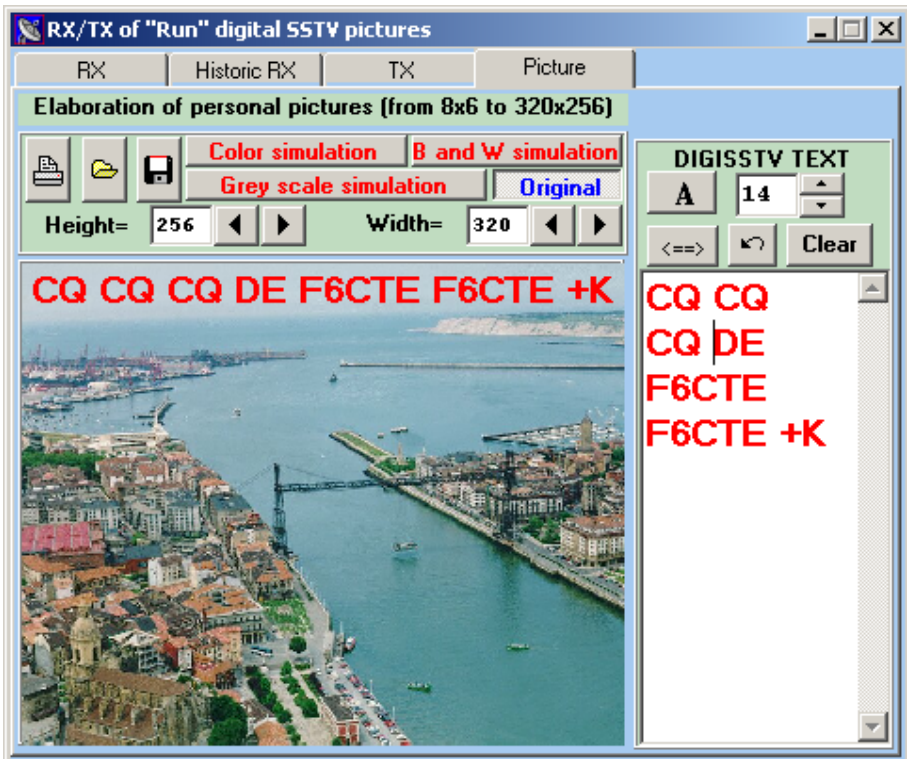
1) The 3 starts of line signals and the end of picture signal (bit 1 X bit 1 with X composed of 17, 18, 19 or 25 bits "0") are completely linked to the protocol previously described as they permit to detect the different picture types (colors, grey scale and black and white) as well as the end of picture transmission.
So, these 4 bits strings must be alone on the transmission modes (as in PSK63F and in PSK220F) where the protocol "Run" is used.
Note: the probability to meet these bits strings is very weak and the one to validate them through the "Check-Sum" in Packet is totally negligible.

2) At the present time, the 3.7 version of Multipsk implements this protocol on the PSK63F, PSK220F and Packet (300 and 1200 bauds) modes.


RX/TX of "Run" digital SSTV pictures
RX
Historic RX
TX
Picture
Format: 320x220 color, 20:22:39 UTC, d=9mn 34s
End of picture reception
Auto. recording
Clear
Selective clear
Init
Help
Auto. complement
Complement
100 % Line:220
Complement and record
Panoramic
Exit
Overload
Log book
DXKeeper
DXK fields
Help on right click
BPSK31
PSK10
FEC31
QPSK31
PSK63
MT63
PSKAM 10
31
50
PSK63F
PSK220F
DIGISSTV
CW
CCW
PACTOR 1
TOR A
AM. ARQ
AM. FEC
THROB
THROBX
ASCII
MESK8
MESK16 + SSTV
HE FAX
SSTV
FELD H.
PSK H.
HELL 80
FILTERS
BINAURAL
Spectrum
Waterfall
Band KHz (P450=+)
2.5
3.3
4.3
Color
10
AGC
Grey
INFO
STAT
It is a digital SSTV protocol (DIGISSTV), allowing transmission pictures in colors, in grey scale or in black and white, where the picture may be transmitted among PACKET, PSK63F or PSK220F text.
The "Run" protocol has several peculiarities:
1) The goal is not, here, to transmit a binary picture of an already compressed file but:
- to load a picture (BMP or JPG) on an array of pixels,
- to compress it in the most appropriate way for radio transmissions,
- to manage its transmission and reception.
2) A SWL or a Ham listening must be able to decode this digital picture either at the beginning of the transmission or while the transmission is in progress, hence...
Run320x220C
Snapshot
Print
Fonts
Clear
Double
Text
Height
33
08/05/05 20:41:04 UTC
Démarrer
C:\
Multipsk
FR
22:41



It is a digital SSTV protocol (DIGISSTV), allowing transmission pictures in colors, in grey may be transmitted among PACKET, PSK63F or PSK220F text.


RX/TX of "Run" digital SSTV pictures
RX
Historic RX
TX
Picture
Elaboration of personal pictures (from 8x6 to 320x256)
Color simulation
B and W simulation
Grey scale simulation
Original
Height=
256
Width=
320
CQ CQ CQ DE F6CTE F6CTE +K
DIGISSTV TEXT
A
14
<==>
Clear
CQ CQ
CQ DE
F6CTE
F6CTE +K