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# DIGIMODE IDENTIFIERS

## Introduction

The identification of a digital amateur mode (commonly called digimode ) can't be done automatically by software. This is due to the diversity of the modulations used (BPSK, QPSK, FSK, MFSK, IFK, OOK...), speeds used (from 1 to 9600 bauds), codings used (convolutional, Reed Solomon or other). Also, it may have several transmissions of different types on the same bandwidth.
However, in the particular case of only one modulation and only one transmission in the reception band, a mode can, possibly, be automatically identified, as for example:

- BPSK on Multipsk,
- FSK on RadioRaft software of François Guillet, F6FLT. Actually, this soft permits automatic identification of many FSK modes (for one transmission on the bandwidth).

The software can also measure speed modulation and/or shift to help the user to determine the mode.
To conclude this paragraph, the problem of automatic identification of digimodes, even if exciting, cannot be solved at the present time (perhaps, it will be solved in the future with processings based on artificial intelligence algorithms). However, it exists software as "Signals Analyzer" which helps on the determination of the mode used.

Some modes are simple to identify by the user, either because their frequency is well known (BPSK31 on 14070 KHz, for example) or because the visual signature on the waterfall or the acoustic signature is characteristic (RTTY 45 bauds for example).

But for the other digimodes (more or less exotic), it is very difficult to identify the mode or the sub-mode used, with the simple visual and/or acoustic traces. Therefore the need of digimodes identifiers.

At the present time, the only official identifier is the one which defines the analogical SSTV sub mode used (Robot 36, Martin 1...). It works perfectly but it is limited to SSTV.

In general, it is possible to send (at 20 wpm on Multipsk) a small CW text before each digimode transmission. But this is rarely used. Moreover, CW is not always understood and, even if understood, the latency time before the cerebral decoding occurs, causes on to lose the beginning of the message.

Here are two new identifiers of modes (RS ID and Video ID) which could simplify the identification of digimode transmissions, if they would be more widely used..

# Reed-Solomon identifier (“ RS ID ”) of mode and frequency

## Origin

The "RS" ("RS" for "Reed-Solomon") identifier has been created by the author (Patrick Lindecker) and added to the version 4.1.1 of Multipsk (November 2006).

## Main use

The "RS" ("RS" for "Reed-Solomon") identifier allows the automatic identification of any digital transmission done in one of the RX/TX modes handled by Multipsk (122 modes and sub-modes in version 4.15, from BPSK31 to MIL-STD-188-110A).

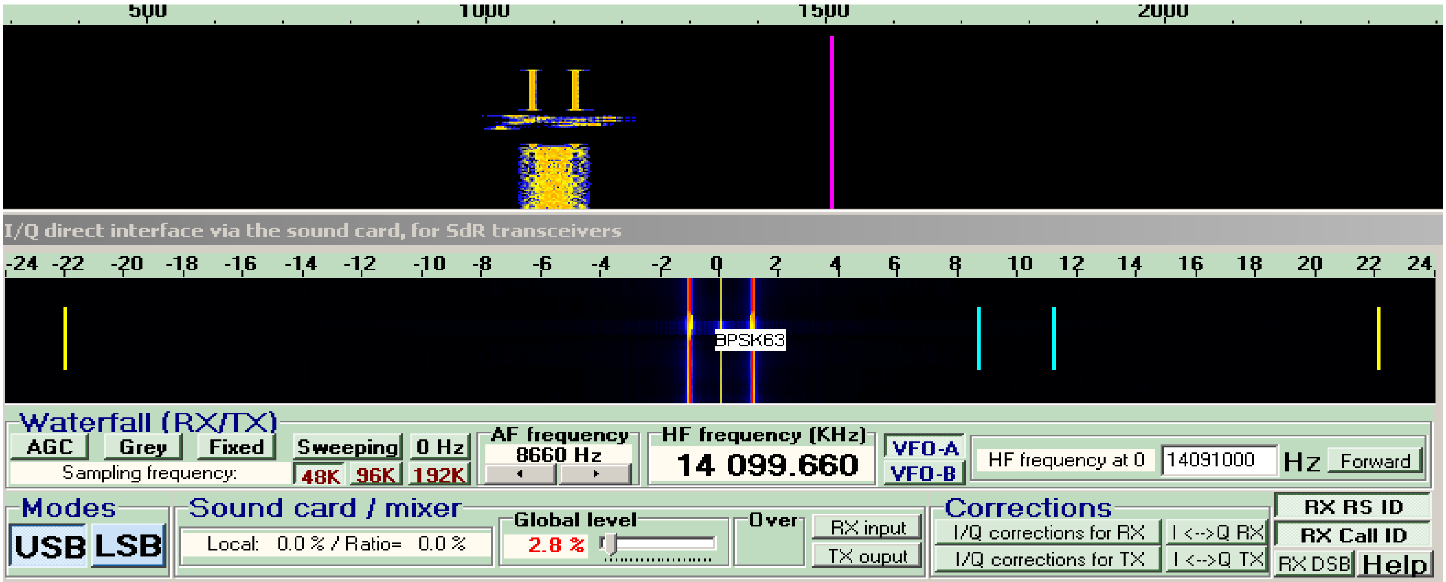
> Note: all RS ID are detected by Multipsk but not all modes are decoded by Multipsk as, for example, FDMDV mode from Cesco (HB9TLK) or THOR modes from Dave (W1HKJ). Each decoding program decodes a subset of the set of modes detected through the RS ID.

On reception of a RS ID, two events occur : the mode used is detected and the central frequency of the RS ID, which is also the central frequency of the identified mode, is determined with a precision of 2.7 Hz.

As soon as this identifier is received, Multipsk switches on the received mode and frequency and decodes immediately the QSO in progress or the call (CQ). This identifier is transmitted in 1.4 sec and has a bandwidth of 172 Hz. Its detection is done down to a Signal to Noise ratio of about -16 dB, so with a sensitivity equal or better than the majority of the digital modes (RTTY, PSK31...), except several modes as PSK10, PSKAM10, THROB, THROBX or JT65.
Note: consequently, it could appear that the RS ID be detected but the call or the QSO could not be decoded due to a too weak signal.

This identifier can be transmitted, first, before each general call or prior to each answer in a QSO.
The search is, in general, done in the bandwidth 200-2500 Hz. For this bandwidth, the equivalent CPU load is negligible. But the search can also be done on a 44 KHz bandwidth from a SdR receiver. In that case, the equivalent CPU load is about 500 MHz. Below is a snapshot of the SdR Multipsk interface on reception of a RS ID.

Note: false detections are theoritically possible but statistically extremely rare (never seen by the author even on 44 KHz bandwidth), this due to a very strong autocorrelation function.

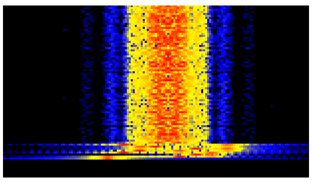



At the present time, five programs offer the RS ID:

- PocketDigi by Vojtech (OK1IAK)
- FDMDV by Cesco (HB9TLK)
- DM780 by Simon (HB9DRV)
- FLdigi by Dave (W1HKJ)
- Multipsk by the author (F6CTE)

RS ID programs sources are available either, in C++, from Vojtech (OK1IAK) or from the author (in Delphi and including SdR detection).
The list of the RS ID identifiers (in form of numbers) associated to digital modes is managed by the team of the programmers listed above. This list is diffused on the DigitalRadio Yahoo group at each change.

For example, here is the PSK63 RS ID (root) received just before the PSK63 transmission itself (trunk).



# Principle

Each mode corresponds to a number which is transformed in a particular Reed-Solomon sequence. This RS coding ( RS(k=4,t=6) ) is defined by the parameters k=4 (number of bits per symbol), n=15 (=2^k-1, number of symbols by RS sequence) and t=6 (maximum number of errors which could be theoretically fixed). It means that each RS sequence is composed

of 15 symbols of 4 bits, among which 3 (=n-2xt) carry data. In other words, 12 bits (3x4) are available to define the mode number. Consequently, the number of possibilities would be equal to 4096 (2^12).
In addition, even if the maximum number of errors which could be fixed is equal to 6, it is limited to one correction so as to have a negligible probability of false detection (by increasing the Hamming distance between any random sequence and the selected sequences).
However, it has been conservatively supposed that two RS ID could be send successively and that two RS ID could be also sent in juxtaposed frequencies. As false RS ID detection with part of one and part of the other (either in the time domain or the frequency domain) must be avoided, it has be determined a sub-set of RS ID which are really mutually independent (“orthogonal"), i.e. two contiguë RS ID sequences can't produce a valid but wrong RS ID code. This sub-set is only composed of 272 possibilities. It is the first choice.

Each symbol is transmitted in a MFSK modulation. There are 16 possibilities of frequencies separated by 11025/1024=10.766 Hz, each symbol transmission being done on only one frequency for a duration equal to 1024/11025x1000=92.88 ms. So, the 15 symbols are transmitted in 15x1024/11025=1,393 s.

To simplify, the decoding is done according to a “ brute force ” algorithm type where all the possibilities are explored and not according a classical Reed Solomon decoding algorithm. The possible found solutions are sorted according to their distance (0 or 1) to a valid solution and according to a pseudo signal-to-noise ratio (peak power/average power). The advantage is given to the solution having the lowest distance with the biggest pseudo signal-to-noise ratio.
In addition, Vojtech (OK1IAK) uses a “ hashing ” technique to accelerate the calculation.

For each semi-step of time (46.44 ms) and for each semi-step of frequency (5.38 Hz), the program attempts to detect a RS ID extending for the last 1.393 seconds. So each second, about 8500 possible RS ID (depending on the selected bandwidth) are tested (depending on the bandwidth). As the probability of false detection is practically nil, there is no problem to test so many possibilities.
The analysis is based on FFTs (Fast Fourier transform) of 2048 points at 11025 samples/sec, regularly done at each semi-step of time (46.44 ms).
For SdR detection, the sampling is done at 44100 Hz, through a decimation from 48, 96 or 192 KHz. It permits to detect any RS ID within a bandwidth of 44 KHz.

As it is a free error transmission, in presence of a RS ID identifier, there are two solutions:

* either the RS ID identifier is not received because the signal is too weak,
* or it is received and it is correct, the probability of detection of a wrong RS ID identifier being almost nil.

Transmission
In all modes (including MT63, SSTV, Fax, FELD HELL...), a RS ID can be transmitted. It is sent on the average transmission frequency, except in SSTV where it is sent on the synchronization peak as displayed on the waterfall (between 1150 and 1400 Hz).

Relatively to the average transmitted power:
The ratio between the average power and the maximal power is equal to 1 because the RS ID is transmitted in MFSK, so the transmitted power is maximum.

# The video identifier of mode (“ Video ID ”)

## Origin

The initial idea came from Henri (F6BAZ), who advocated (in December 2005) that the waterfall be used to display the name of the mode in CMT Hell (see http://f6baz.free.fr/windrm4.jpg).
The author (Patrick Lindecker) found the idea interesting and integered it to the version 3.12 of Multipsk (January 2006), for all modes.

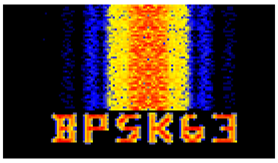
## Main use

The mode label and/or other information is sent in CMT Hell (Hellschreiber) before the main transmission. This identifier will be visible in the "waterfall" of the receiving station.
The identifier can be transmitted either :

- in an horizontal shape : the transmission is quick but not powerful,
- or in a vertical shape : the transmission is slow but is more powerful because more concentrated (much less carriers).

For example, just before the general call ("CQ") in BPSK63, "BPSK63" will be sent automatically on CMT Hell. The receiving station will see "BPSK63" displaying on his "waterfall" and the operator will switch immediately to the BPSK63 mode (the switching is not automatic as with the RS ID).

Here is what is seen in the waterfall (Video ID followed by the BPSK63 transmission itself).




At the present time, four programs propose the video ID (as far as I know):

- DM780 by Simon (HB9DRV)
- FlDigi by Dave, W1HKJ
- Digipan by Skip, KH6TY
- Multipsk by the author

# Principle

Each character is transformed in capital letter, if necessary, then in pixels matrix according to the selected font (see hereafter).
Apart from the MT63 (which is a particular case), the transmission is done at 11025 samples/second. The FFT is done on 4096 samples, using 2048 samples of the previous FFT buffer, so with, in fact; new 2048 points only. This comes to double the display speed, with a light dependency between successive pixels. Consequently, between 2 pixels, it will be found intervals of frequency and time of respectively:

 * 11025/4096 = 2.691 Hz,
 * 2048/11025 = 0.1858 second.

The pixels are transmitted in the C(Concurrent)MT Hell mode (for mode details, see the site of Murray, ZL1BPU :
http://www.qsl.net/zl1bpu/FUZZY/MT_intro.htm).
To sum up, the transmission is done on many juxtaposed carriers sent in parallel. The presence or the absence of a carrier determines either a trace (dot) on the waterfall or an absence of trace. So each line will be composed of a set of dots and a set of lines will constitute a set of characters.
Note: to keep linear (without any overload), each carrier will be limited in amplitude.

The mode name is centered in the middle of the mode bandwidth (see the example about BPSK63 above).
If the transmission is reversed (for FSK, MFSK and QPSK modulations), the name is also reversed (it will be written from right to left). Remember normally, in HF, digimodes are transmitted in USB not in LSB, and this independently from the frequency.

Mode names will be transmitted in their standard name: "BPSK31", "BPSK63", "MFSK16", "PAX2", "FAX"..., if they are not ambiguous.

However, there exists several special cases. For example, MT63 name will be "MT63 bandwidth interleaving" type with for the bandwidth: "500", "1K" (for "1000") or "2K" (for "2000"), for the interleaving "VST" ("Very short"), "ST" ("Short") or "LG" ("Long"), so a maximum of 12 characters ("MT63 500 VST", for example). See the Multipsk help for more details about the way to express mode names.

The characters can be sent in different Hellscreiber fonts ("Hell 80 double", "Feld Hell double, normal", "Feld Hell double, bold").

<u>Relatively to the transmitted mean power:</u>
The transmitted mean power will be weak due to the fact that it is necessary not to saturate the signal to keep the text readable. Thus, the more there will be "horizontal" pixels to transmit, the less the mean power will be important. However, the human capacity to read a very noisy text compensates for this weak power.