

Digital Modes: the Future of Amateur Radio?

An introduction to PSK31, MT63, and Hellschreiber

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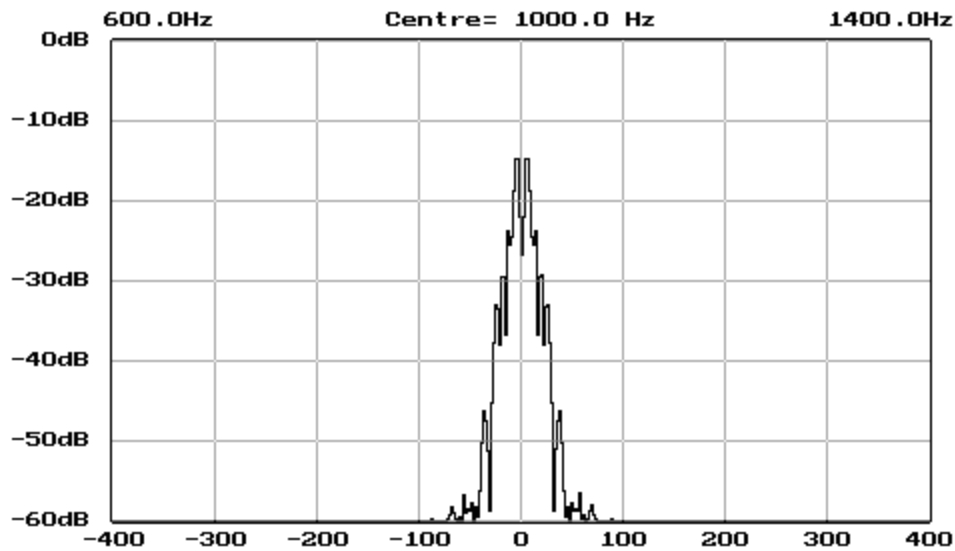
PSK31

- Invented by Peter Martinez, G3PLX
- First PC soundcard version 26 Dec 1998
- Intended for live keyboard-to-keyboard QSO
- Uses varicode character coding for 50 wpm
- Easy to use and monitor
- Gives very good copy under low Eb/No numbers and is thus suitable for QRP

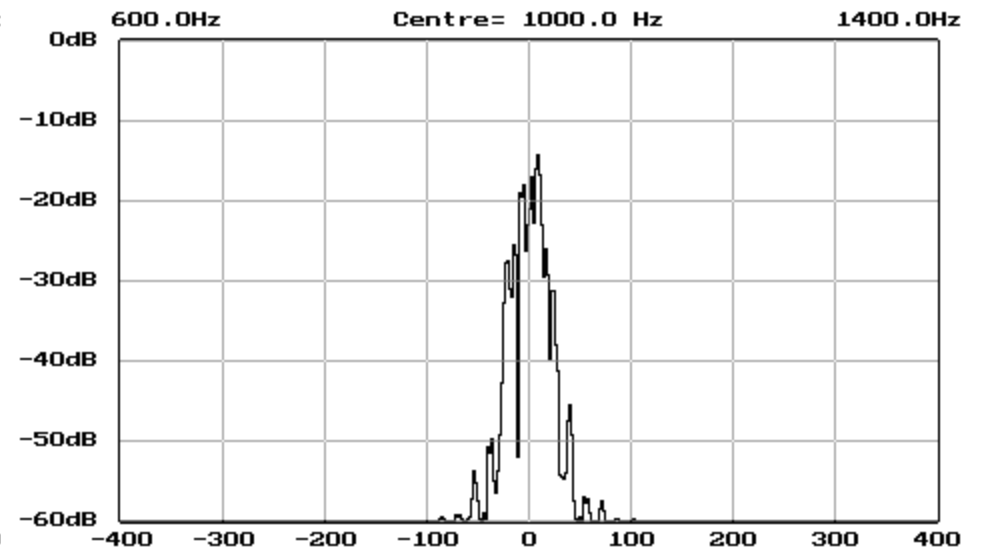
PSK31 (continued)

- Instead of using FSK or on/off keying, uses BPSK or QPSK with a Viterbi decoder
- Is available for free for many platforms, including Windows with soundcard
- Uses advanced DSP and narrow bandwidth (31.25 Hz) techniques
- Tx duty cycle is 50% idle, 90% maximum
- The greatest activity is around 14070.15

Bandwidth



BPSK



QPSK

Spectra obtained with EvmSpec (from PSK31 homepage)

PSK31 Operation

- BPSK is generally used for calling CQ and routine operation
- QPSK gives much better performance with fading and flutter
- QPSK has an 800 msec one-way delay, or 1.6 sec round-trip
- PSK31 requires a synth or stable VFO rig
 - BPSK tuning needs to be within 8 Hz
 - QPSK tuning needs to be within 4 Hz

MT63

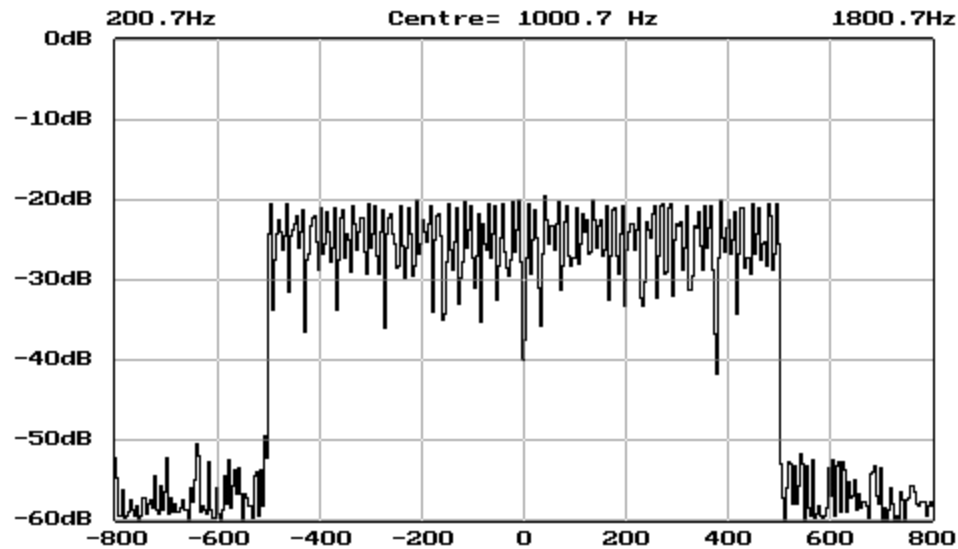
- Developed by Patwel Jolocha SP9VRC
- Encodes information using 63 modulated tones
- Sounds unusual, like a roaring noise
- No connection process, as in AMTOR, Packet, or PACTOR
- Outstanding performance when conditions are both weak and unstable.

MT63 (continued)

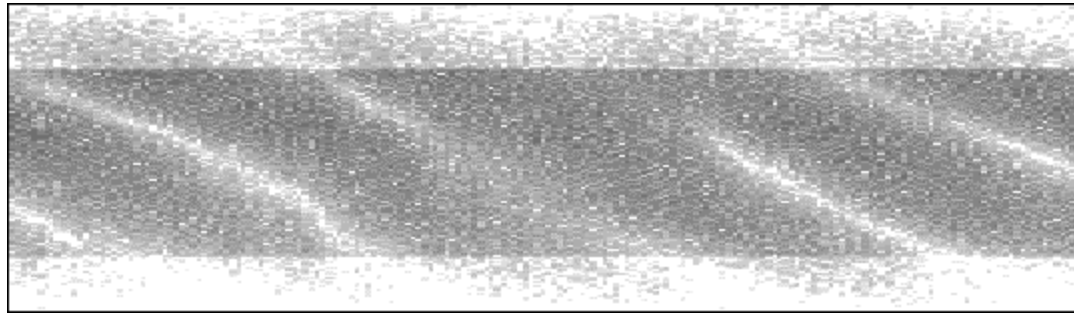
- Spreads signal in time (several seconds) and space (500-2000 Hz)
- Forward Error Correction (7-bit ASCII encoded into 64 bits using a Walsh function) can result in 100% copy even if 25% of a character is obliterated
- Clumsy (slow) operation due to FEC delay
- Very aggressive: causes interference to other modes, but itself is little affected by other modes

MT63 Characteristics

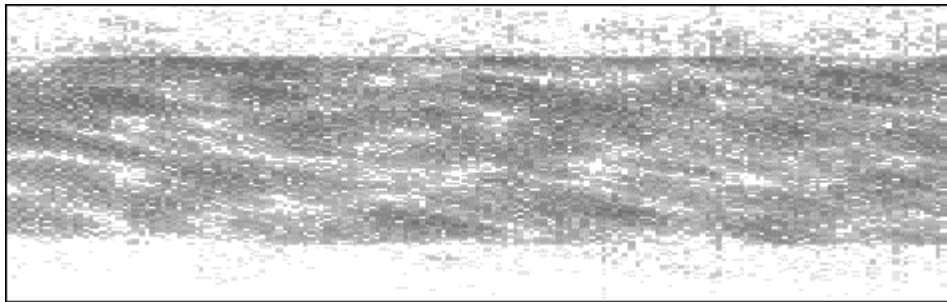
Bandwidth	Audio Range	Symbol Rate	Char Rate	Interleave/char
500 Hz	500-1000 Hz	5 baud	5 char/sec	6.4 or 12.8 sec
1000 Hz	500-1500 Hz	10 baud	10 char/sec	3.2 or 6.4 sec
2000 Hz	500-2500 Hz	20 baud	20 char/sec	1.6 or 3.2 sec



100% Copy in Presence of Complex Fading with MT63



10 Watts on 14 MHz



50 Watts on 3.5 MHz

Hellschreiber (Hell Writing)

- Patented by Rudolf Hell in 1929
- Used by the German Condor Legion during the Spanish Civil War (1933). During WWII, Hellschreiber was widely used for field portable military communications.
- Still used today in the original format
- Visually readable mode
- Most DX on 14063 kHz - 14070 kHz

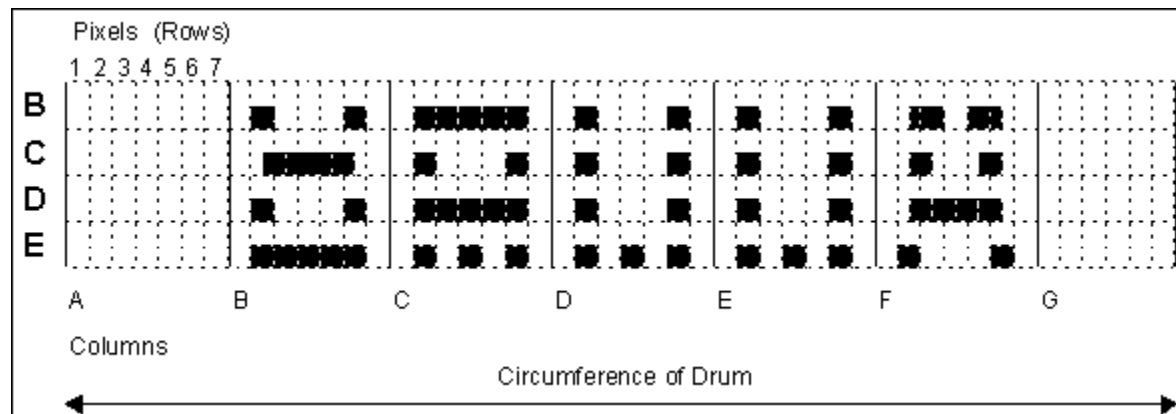
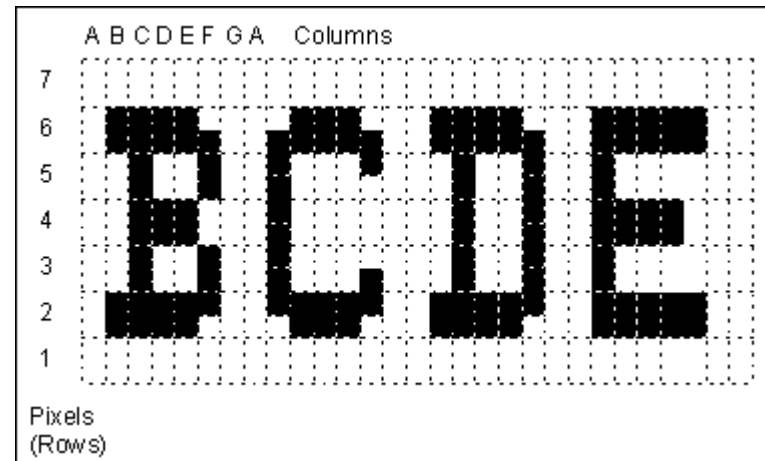
Feld-Hell (Field Hell)

- Feld-Hell characters are sent as a series of dots at 122.5 pixels/sec, using a CW transmitter or by sending tones to an SSB transmitter.
- Black dots are represented by a CW dot (key down), and white spaces by a space as long as one dot (key up).
- Low duty-cycle: ~22%

The Siemens & Halske A2 Feldfernschreiber (1944)



Feld-Hell 7x7 Character Set



Feld-Hell Timing

- Each character takes 400ms. Since there are 49 pixels per character, each pixel is 8.163ms long. The effective baud rate is $1/8.163 \text{ ms} = 122.5 \text{ baud}$, and the throughput is 2.5 characters/sec, or about 25 WPM.
- Raised cosine filtering results in $2 * 122.5 = 245 \text{ Hz}$ bandwidth.

PSK-Hell

- Recently invented by Murray ZL1BPU and implemented by Nino IZ8BLY.
- Uses Differential Phase Shift Keying, which relies on detection of a change in phase. One state (black) is defined as no change in phase from one dot to the next, while the other state (white) is defined as a reversal of the carrier phase from the previous dot.

PSK-Hell (continued)

- Matrix is only 7 x 6, seven columns of six dots (42 dots). This reduction in dots per column allows a lower baud rate (105 baud) for the same column rate and text speed as Feld-Hell.
- High Tx duty-cycle: ~90%

MT-Hell (Multi-Tone Hell)

- Each row of dots or pixels in the character is at a different frequency, with quite different (much relaxed) timing, and thus is transmitted in the frequency domain.
- Since columns are always sequential, there is no notion of synchronism in MT-Hell.
- Reception of MT-Hell requires a technique called the Fast Fourier Transform to convert the signal back into a human readable form.

C/MT-Hell

- C/MT-Hell or Concurrent MT-Hell uses many tones (seven or more), which are often transmitted at the same time.
- C/MT-Hell has the following potential advantages:
 - Speed, since several dots can be sent at the same time
 - Better readability, since more dots provide better resolution
 - Better looking text, since the characters need not slope and many fonts can be used

S/MT-Hell

- S/MT-Hell or Sequential MT-Hell uses only a few tones, typically five or seven, but never more than one at a time.
- S/MT-Hell advantages:
 - Weak signal performance, since all the transmitter power is applied to a single dot
 - High efficiency: since the transmitter need not be linear, Class C transmitters can be used
 - Very simple transmitter requirements - easily adapted to QRP and LF transmitters
 - Simple signal generation with a PC, even via the PC speaker or a Hamcom interface

Appearance of Hell Modes

- Feld-Hell text is usually very sharp and may lean slightly to the right, and is always double printed.
- Sequential MT-HELL text leans strongly to the right, and may have a dotty (pixellated) appearance.
- Concurrent tone MT-HELL has very detailed characters, and is always upright (unless the user has chosen an italic font!)

Summary

- PSK31 in the USA has reached “critical mass”: there are signals on HF, especially 20 meters, at almost any time
- MT63 sees limited activity. Its use of wide bandwidth is controversial.
- Hellschreiber is a popular mode in Europe, but there is limited activity in the USA
- PSK (and to a lesser extent, Hell) are great for QRP and restricted antenna installations due to great performance with low Eb/No.

Amateur Radio Digital Mode Information Resources

- Official PSK31 Homepage
 - <http://www.kender.es/~edu/psk31.html>
- Fuzzy Modes (and MT63) Web Site
 - <http://www.qsl.net/z11bpu/>
- Digipan PSK31 Software
 - <http://members.home.com/hteller/digipan/>
- IZ8BLY Hellschreiber and MT63 Software
 - <http://space.tin.it/computer/aporcino/>
- Slides of This Presentation
 - <http://www.nerc.com/~jdegood/tcf2000.pdf>