All Things Digital

Amateur Radio for the 21st Century

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This is an updated rewrite of my original Hellschreiber article published in APRS Thunder Bay (2009 spring issue). Frank Dörenberg, N4SPP, and Murray Greenman, ZL1BPU, were both instrumental in assisting me with this revamped version, and my sincere thanks to them for their help and permission to use material from their websites: http://www.hellschreiber.com and http://www.qsl.net/zl1bpu/HELL/Index.htm.

WHAT THE HECK IS HELL?

Dr. Rudolf Hell (1901-2002) is perhaps the least known of the great modern inventors, and with nearly 1,000 patents (separate or jointly) he easily rivals Thomas Edison, yet I doubt many people know his name. His long life spanned two centuries and his inventions are found in everything from radio and television, to computers! In 1929, Dr. Hell invented a method of transmitting and receiving text on a wired circuit (via electrical pulse or tone), along with a wireless method (on/off keyed [OOK] continuous wave or amplitude shift keying [ASK]) using small, light and portable equipment which was a tremendous improvement over the large, heavy, and not-so-portable teletype printers of the day.

Dr. Hell's objective was to design a practical system for use by press agencies, and his genius was in the design of a special font with its method of encoding and decoding: convert a character to digital form, store it in a memory bank (mechanical, magnetic, optical, etc.), retrieve the data from memory, and transmit it as in sequential bit stream; receive and reassemble the sequential stream, and print the character.

The original mechanical system used only upper case characters, numbers, and four symbols + - / ? plotted on a black and white 7x7 grid. Each black or white dot (pixel or pel) is transmitted in a specific sequence and at a specific rate. What's even more interesting is that Hell doesn't use or need start/stop, synchronization bits, error correction, or "handshaking". The transmitting station starts sending characters and the receiving station starts printing characters. It's the person at the other end who has to make sense of what is being received!

As per the convention of the time, the system of radio text printing or writing (German verb: schreiben) was named after its inventor and became known as “Hellschreiber”, but during WWII, German army field (German noun: Feld) radio operators called it “Feld Hell”. Interestingly, the word “Hell” has other German meanings, so non-German speakers often mistranslate Hellschreiber to mean: “light writer”, “bright writer”, or “clear writer”.

THE TWO PIXEL RULE

With reference to Figure 1, you can see a slight problem by looking at the right sides of the “B” and “C”; how the heck do you transmit half a pixel (black or white)? Well, Dr. Hell came up with a unique way to do this and also increase the vertical resolution but not the bandwidth!

In the mechanical Feld Hell version, vertical elements were transmitted as half-height pixel pairs and no single half-pixel would ever be sent. A half-pixel is equal to 4.0815ms (on or off), so the end result was a pixel pair transmitted for 8.163ms, or a triplet for 12.245ms. For an analog machine using gears, belts and sprockets to “slip” in a half-height pixel was/is truly amazing!

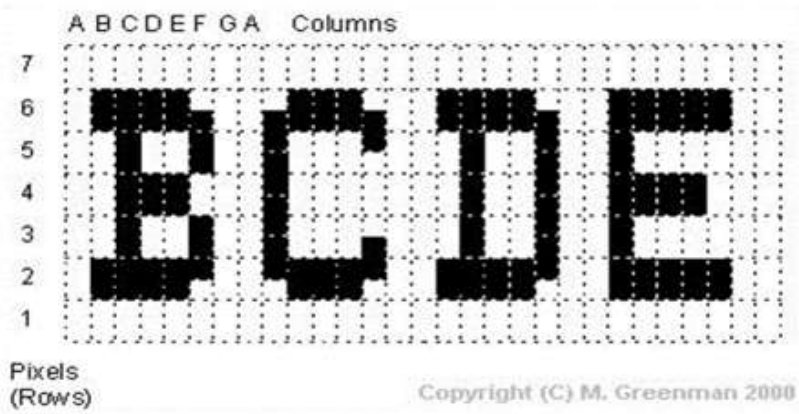


Figure 1: Mechanical Feld Hell 7x7 Character Font Matrix

The standard Hell font is plotted on a 7x7 black and white grid. There are blank (whitespace) not-transmitted pixels at the top, bottom and between characters (for spacing) and transmitted (black) pixels. The transmission serial stream sequence is: A1, A2, A3…up to A7 then B1, B2, B3…and so on until all the character elements are transmitted. Originally, radio Feld Hell was transmitted using OOK CW or ASK AM keying at 8.163 milliseconds per pixel, and the landline machines used a 900 Hz tone to represent a white pixel.

The transmission rate is 150 characters/minute and the effective data rate is 122.5 bps (bits per second), or about 25 words per minute. The CW duty cycle averages 25% (6% lowest, 39% highest) and is very low compared to most digital modes (PSK and FSK have 100% duty cycles). However, rapid keying of CW transmitters causes “hard keying” (key clicks) and must be properly contained using shaping and low pass filters to prevent unwanted sidebands

Diagram courtesy of Murray Greenman, ZL1BPU and used with permission.

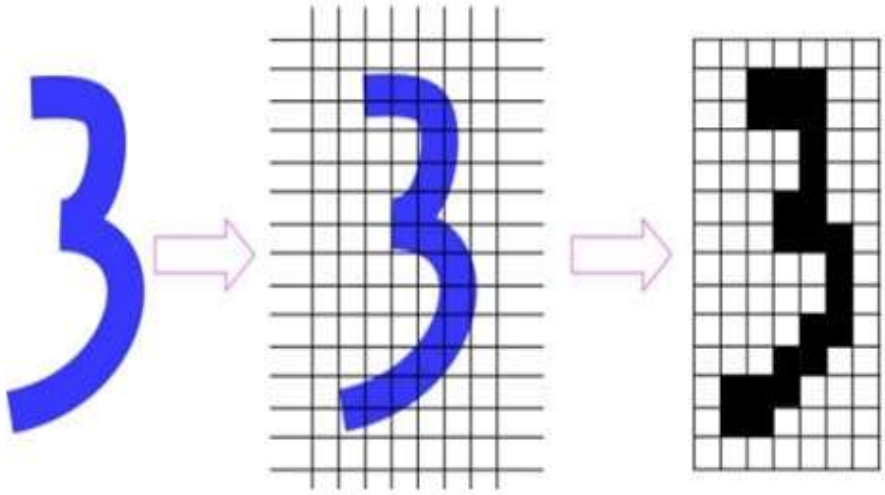
Note: Rapidly keying a transmitter on and off causes “hard keying” and produces unwanted side bands so shaping and low-pass filter circuits are required to prevent this. Transmitters also need some “recovery” time to switch between the two states, so Dr. Hell decided the minimum keying should never be less than 8.163ms for implementation of the Two Pixel Rule. However, modern Hell variants take certain “liberties” with the rule and therefore aren’t compatible to the original mode.

Today, digital computers make it very easy software emulate a Feld Hell transmitter and receiver except there are no moving parts! Frank's graphics (Figures 2A and 2B) show how we create a modern Hell font by digitizing the character using a 14x7 grid (representing the vertical half-pixels). Each Hell character is 98-bits (light or dark) and stored in RAM (random access memory) as a sequence of 1's and 0's. Each character's bits are shifted in sequence to software emulate the Two Pixel Rule. As long as bits are 1 (or 0) the transmitter will remain on (or off).

FUZZY WUZZY WAS A WHAT?!

Both Hell and the Morse code are considered "pseudo-digital" modes because no start/stop, error correcting, synchronization bits, et al are used or required for transmission or reception. When Hams use Morse code, we don't have to manually encode/decode the message (our brain treats it like a natural language), and with practice you hear words and sentences, not dots and dashes. It's the receiving operator who has to make sense of the message and deal with any noise, fading, interference, or sloppy sending!

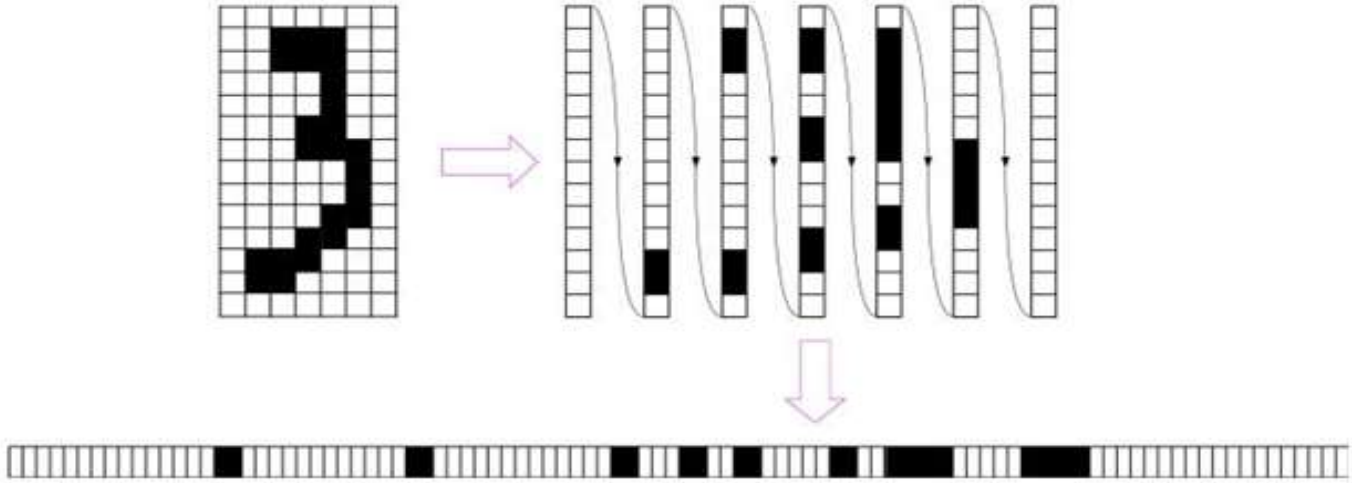
Figure 2A: Example Hell Font Character Digitizing



In this example, the written (analog) number 3 is placed on a 14x7 grid (two pixel rule evolved from the 7x7 grid) and converted to a rasterized (digitized) array of light and dark pixels. There are blanks rows (left, right, top and bottom) for character spacing. Once an entire alphanumeric set is digitized, it's stored in computer random access memory (RAM) for later retrieval.

Diagram courtesy of Frank Dörenberg, N4SPP and used with permission.

Figure 2B: Example Hell Font Character Transmission



To transmit a Feld Hell character, the computer retrieves its digital representation from RAM and starts from the bottom left-hand corner and goes up and down column by column with the dark pixels representing binary 1 (mark) and the white pixels representing binary 0 (space). This forms a continuous transmission stream for OOK CW, ASK AM or AFSK USB. Each character is 98 bits (14x7) and takes 400ms to transmit.

Diagram courtesy of Frank Dörenberg, N4SPP and used with permission.

In the late 1990's, the human method used to encode and decode visual, audio, or physical patterns into language, text, music, art, etc., was given the very scientific term "fuzzy logic", and this defines the pseudo-digital modes. Humans have the innate ability (with various levels of complexity and familiarity) to communicate with each other without speaking (we call it "body language"); facial expressions, hand gestures, eye contact (or lack thereof) contain as much or more information than words (a picture is worth…). If someone gives you "the finger", it will usually provoke an emotional response from you, but no words were said except your brain's fuzzy logic interpretation of the senders intended message to you!

HELL ON A COMPUTER

We are going to transceive standard Feld Hell using computer software and a soundcard, connected to an SSB transceiver with a soundcard-radio interface. HF soundcard Feld Hell always uses USB (upper sideband) regardless of the band. USB has become the de facto standard for most digital modes (there some exceptions). A single audio tone is injected into the transceiver to produce AFSK (audio frequency shift keying) emulating OOK or ASK Hellschreiber, however, the signal bandwidth used varies with OOK or ASK. See http:///www.nonstopsystems.com/radio/hellschreiber-bandwidth.htm.

Using AFSK Feld Hell, it's the soundcard that's rapidly switched on and off while the SSB transmitter remains in locked transmit mode until the end of the transmission (think about it) so you with require an interface with either VOX PTT or serial port PTT keying (Figure 3). With CW Feld Hell, it's the transmitter that's switched rapidly switch on and off, and yes, any CW transceiver can be easily modified to transceive both Morse code and Feld Hell!

Figure 3: Various Soundcard Interfaces

Left is the Buxcomm Rascal interface with computer serial port PTT control and requires no external power. Right (top) is the Tigertronics SignaLink SL-1+ VOX PTT interface and requires an external 9-12v DC power source. It has a PTT delay button to provide a fixed delay (internally adjustable). Both it and the Buxcomm plug into your computer's mic/line and speaker soundcard ports, and connect to your transceiver. Audio and recording level control is via the Windows sound mixer panel. Lower right is the Tigertronics SignaLink USB external soundcard VOX PTT interface. It plugs into your computer via a USB port for both audio over USB and DC power; it has its own audio level controls and variable PTT delay. The more money you spend, the more features and convenience you get.

Feld Hell's sound is very unique, and you'll never forget it once you hear it. I call it "little frog with laryngitis", so it's very easy to identify from all the other digital modes. But it's not a very melodic sound, and if listening to a hoarse croaking frog doesn't appeal to you, just turn down the volume and watch the text being printed (pixel painted) on your monitor, instead.

Because the Feld Hell receiver gets no help from the transmitting station with any kind of synchronization and doesn't even know in what phase state the original signal should be, all Hell receive text is printed twice to make it easier for us to use our fuzzy logic to decode the message. The way the text is printed tells you how much in or out of signal phase you are (split top and bottom text or half text lines), or if there are timing errors (slanted text to the left or right).

VARIOUS KINDS OF HELL

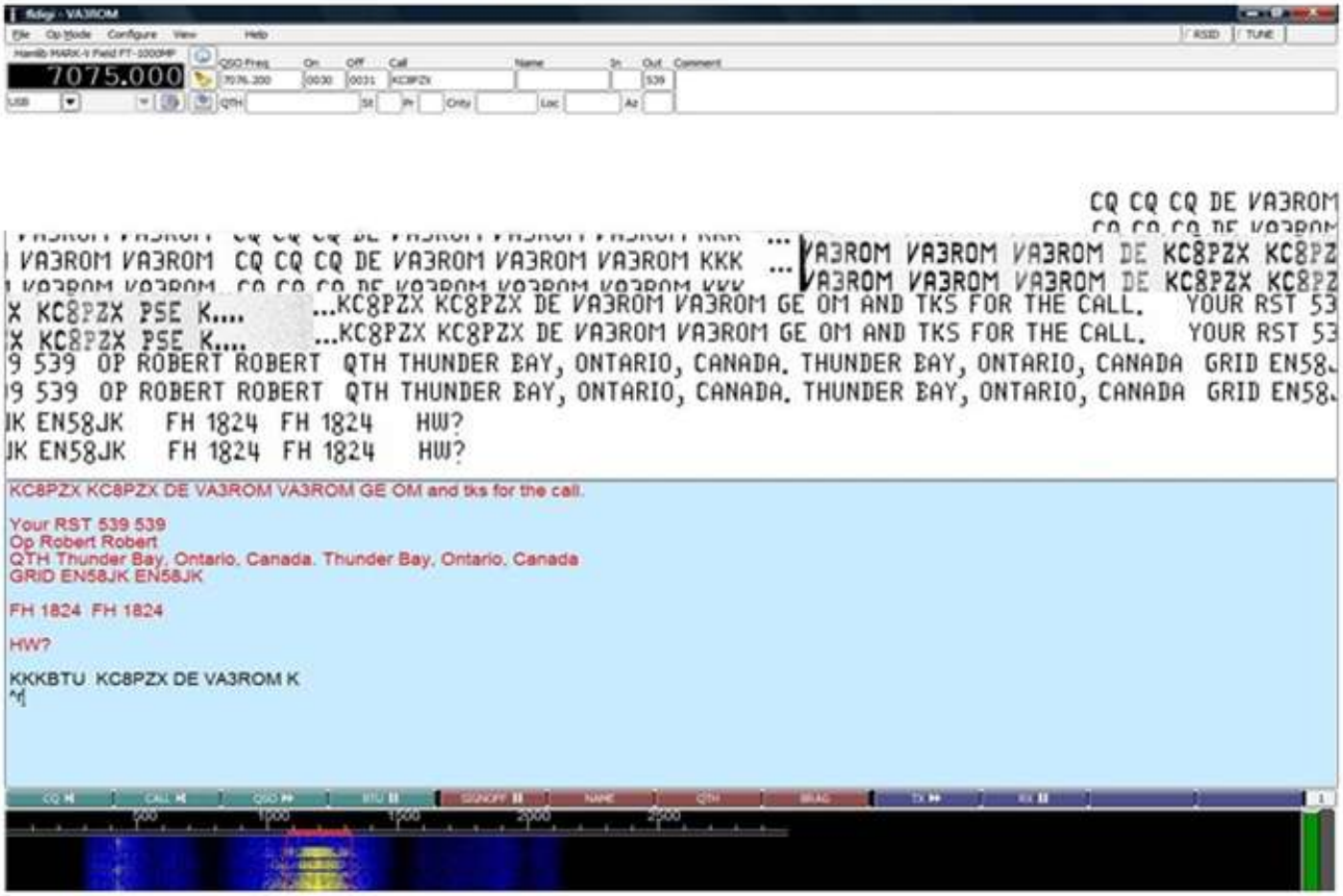
There are many modern variants such as PSK and FM Hell for weak signal work; S/MT (sequential multi-tone) and C/MT Hell (continuous multi-tone) for use with high atmospheric noise levels. The multi-tone modes are decoded using FFT (Fast Fourier Transform) capable programs such as Spectran (http://digilander.libero.it/i2phd/spectran.html) scrolling the waterfall display right to left instead of top to bottom.

Hell's weakness are when there's very heavy fading in unstable atmospheric conditions and other nearby carrier-based signals, but it's often better than voice and other digital modes given Feld Hell's high signal to noise ratio (SNR or S/N), and peak to average power ratio (PAR) or crest factor http://en.wikipedia.org/wiki/Crest_factor. Murray has written an excellent document explaining Hell and its various versions http://www.qsl.net/zl1bpu/DOCS/Hellspec.pdf.

SOFTWARE HELL

There are several free programs: Hellschreiber by Nino Porcino, IZ8BLY, and WinHell by HM Spekink, PA3BQS (you can download them from my website). There is FLDIGI (http://www.w1hkj.com/download.html), and MultiPSK (http://f6cte.free.fr/index_anglais.htm) by Patrick Lindecker, F6CTE, which are free software suites and support many other digital modes.

Figure 4: Software Feld Hell Display



Screen capture of my QSO with Paul, KC8PZX, with Fldigi operating in Feld Hell mode. Standard Morse code operating procedures, abbreviations, etc., are used with digital modes. Dial frequency was 7075 kHz USB, AFSK shifted by a 1200 Hz tone. Fldigi supports many digital modes such as PSK, MFSK, Hell, THOR, Throb, Olivia, MT63, Domino, RTTY and the Morse code. It has versions for Linux, Free-BSD, OS X, and Windows XP to 7.

Note the double text printing for extra readability (upper half of screen). Since the text is perfectly doubled and nearly vertical I'm "locked" on to his signal in both phase and timing. There's not much you can do about phase shifting but soundcard calibration corrects for any timing errors. Most digital modes programs can do this using a free utility called CHECKSR.

CLUB HELL

Many of the soundcard data modes have Internet support groups and online clubs you can join. The Feld Hell Club (FHC) http://sites.google.com/site/feldhellclub is free, and they'll issue you a FH certificate and number (good for life) used for various club contests and communications with other club members; the FHC sponsors contests, conducts Hell Nets, and actively promotes use of this mode.

VIDEO HELL

YouTube has many Amateur Radio instructional videos and Randy Hall, K7AGE, has produced several such as this "Hellish" one http://tinyurl.com/b2ekkv. Randy does a great job of demonstrating the mode using IZ8BLY Hellschreiber, and Ernie Mills, WM2U, wrote a tutorial http://www.qsl.net/wm2u/hell.html.

MY FINAL

What, I'm done with Hell, at least for now. It's a fascinating mode, so simple and elegant. Perhaps someone will write an Android or Apple iDevice version for more portability (there are versions for PSK, RTTY, APRS, and Morse).

My next two columns are going to introduce the easy to program and use microcontroller units (MCUs) called the PICAXE and BASIC STAMP. They are found in many appliances we use every day, and are well-suited for various Ham Radio hardware and software projects (like making a Hell transmitter interface). Novice and "hard core" experimenters will enjoy these ubiquitous devices.—73

Feld Hell Frequencies (USB)

160m 1.804 MHz
80m 3.574 to 3.584 MHz
40m 7.077 to 7.084 MHz
30m 10.137 MHz (Region 1 10.144 MHz)
20m 14.063 MHz (preferred) or 14.073 MHz (Note 1)
17m 18.104 MHz
15m 21.074 MHz
12m 24.924 MHz
10m 28.074 MHz
6m 50.286 MHz

Note 1: For 20 meters, the FHC calling frequency is 14.063 MHz up to 14.069 MHz PSK31 operations are on 14.070 MHz, and the QRP CW club uses 14.060 MHz as their calling frequency. If using 14.073 MHz, be sure to avoid interference with the JT65 segment at 14.076 MHz.

Feld Hell Club Nets

Sunday
20m Net, G0DJA, David, Sundays; **1200 UTC** @ 14.063 MHz
Monday
160m Net, W8LEW, Lou, Mondays weeks 2 & 4; **0300 UTC** @ 1.806 MHz
*10m Net, N3LFC, Larry, Mondays; **1800 UTC** @ 28.074 MHz
Thursday
40m Net, W8LEW, Lou, Thursdays; **0100 UTC** @ 7.077 MHz
Saturday
80m Net, AC7XF, Hugh, Saturdays; **0400 UTC** @ 3.576 MHz

*This net is occasional until the sunspots return. Larry is looking for another net control station (NCS).

The above frequencies and information has been obtained from the Feld Hell Club website.