FROM SPARK TO FT8: OLD VERSUS NEW TECHNOLOGIES IN AMATEUR RADIO

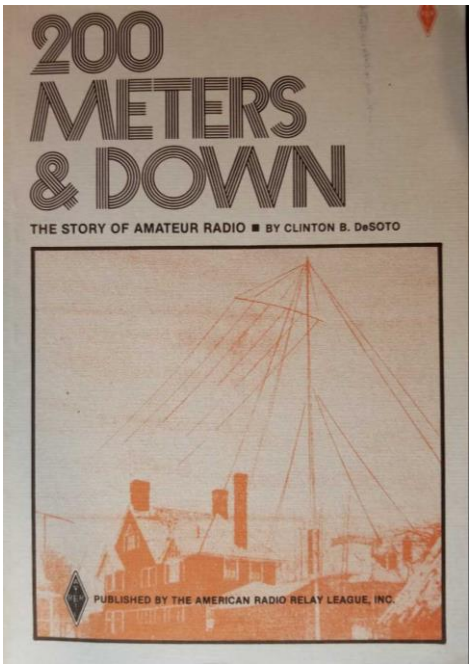
By Wayne Overbeck, N6NB

Since its introduction in August, 2017, the FT8 digital mode has exploded in popularity in both HF and VHF amateur radio. By the end of 2017 more FT8 contacts than CW or SSB contacts were being confirmed on Club Log. Even before FT8's launch, its digital forerunners, the earlier WSJT modes and JT65HF, had already changed amateur radio in many ways.

Perhaps the best way to see FT8's wide acceptance is simply by monitoring the HF bands. It is often possible to see many FT8 traces on a waterfall display on a day when little or no activity can be heard in the CW and SSB subbands.

Created by Dr. Joe Taylor, K1JT, and his development team (particularly Dr. Steven Franke, K9AN, in the case of FT8), these new modes first revolutionized EME and meteor scatter communications in the early 2000s, then swept into other amateur radio uses.

All of this has not happened without controversy. There are those who say these new modes are "destroying amateur radio" and making the efforts of thousands of hams to build big, powerful stations meaningless. Dr. Taylor first encounted that kind of sentiment at worldwide EME conferences early in the new millennium. A number of amateurs, especially in Europe, had built enormous EME antenna arrays and legal-limit transmitters, only to see people with smaller antennas and more modest power start working a lot of the same DX that they could work--by using the JT modes.



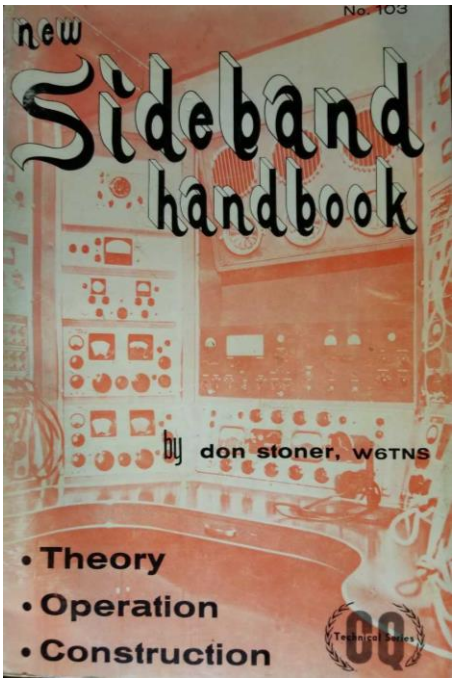
The controversy over the growing use of digital modes is not likely to end soon. However, this is by no means the first time a new technology has emerged to challenge or even supplant older technologies. Over the last 100 years, those who had invested heavily in an older technology have been displeased again and again when something new rendered their technology obsolete. Sometimes old and new technologies coexist side by side, but in one early case federal rules eventually banned an older mode, a story told in Clinton DeSoto's classic history of amateur radio, *200 Meters and Down*.

Soon after radio amateurs got back on the air after World War I, the established spark-gap transmitter technology was challenged by "chirp" stations running much lower power with vacuum tubes--but working greater distances. At first, the noisy spark-gap stations were dominant even using widebanded regenerative receivers. But after World War I, new

stations with quiet, low-power vacuum tube transmitters and more selective superheterodyne receivers--a wartime invention of Maj. Edwin Howard Armstrong--began outperforming the spark giants. Spark-gap transmitting stations quickly became dinosaurs.

A crucial turning point was a series of trans-Atlantic tests in late 1921. Paul Godley, 2XE, went from the U.S. to the U.K. and set up a excellent receiver in a tent in a rainy, foggy place on the coast of Scotland and listened for signals from North America. He heard a lot of signals, and it turned out that most of them were coming from vacuum tube transmitters, not spark gaps. The results of this test were summarized in 1936 in *200 Meters and Down*. On page 74, author DeSoto wrote:

"*The definite, incontrovertible superiority of c.w. over spark had been demonstrated. The rank and file began to concede the victory to the slide-rule minority. It was a year before spark was generally relegated to the scrap-heap, three before it sank into oblivion. But with the lesson of December, 1921 emblazoned before the eyes of amateur radio, the future of tube transmission was assured.*"



Underlying these words was a crucial point about amateur radio. When a new technology is invented, it takes a while before the devotees of the old yield to the new—if they ever do. In this early example, it was not just stubbornness that caused the spark advocates to resist change. DeSoto pointed out that even a small, low-power transmitting tube cost $8 in 1921 dollars. By 1936, a similar tube could be purchased new for 69 cents! At first it wasn't just the "slide-rule minority" that had prevailed--it was a minority with extra money to spend. But with component prices falling while performance was increasing, spark-gap transmitters were banned from the U.S. airwaves by federal law in 1927. Illustrating the bitterness of the spark-vs.-vacuum-tube transition, hundreds of spark transmitter devotees left amateur radio instead of moving to “chirp” transmitters.

In nearly a century since these early trans-Atlantic tests, similar battles between old and new technologies have been fought again and again.

One such battle that is often compared to the modern FT8 controversy is the one fought between amplitude modulation (AM) and single sideband (SSB) advocates in the 1950s.

Before World War II, the scientific community was well aware that SSB was a better mode than AM for long-distance point-to-point voice communications. By the late 1930s there were military and commercial SSB links operating in several parts of the world. That was happening for several reasons. For one thing, SSB is superior to AM by around 9 or 12 dB in communications efficiency. On AM, half of the transmitter power is wasted on a carrier that

doesn't enhance communications but does create a mass of heterodynes on the receiving end in crowded band conditions. Transmitting two audio sidebands instead of just one wastes another 3 dB. And still more signal is wasted in receivers that must copy a broadbanded AM signal instead of a much narrower SSB signal. Moreover, the transmitted duty cycle is much lower on SSB, allowing a transmitter to deliver far more power output for a given amount of plate dissipation.

But all of these scientific realities didn't change the dominance of AM in amateur radio voice work for many years after SSB's technical superiority was proven. There were some practical realities that could not be ignored. For one, an SSB system was hideously expensive in the 1930s. The stability requirements of SSB drove the cost well beyond what most amateurs could afford. Most hams didn't even consider SSB before the war. For another, building such a system back then was way beyond the technical capability of most hams. And SSB had an image problem. The "Donald Duck" sound of voices on SSB was easy to ridicule.

After World War II, some of that changed. Low-cost military surplus ARC-5 transmitters had amazingly stable variable-frequency oscillators that worked at 5 MHz, making it easier to generate a stable SSB signal on 20 meters (14 MHz) and 75 meters (4 MHz) with an SSB exciter operating at 9 MHz (adding 5 plus 9 yields a signal at 14 MHz, while subtracting 5 from 9 produces a signal at 4 MHz). But it was still a technical challenge to get on SSB. That challenge started to disappear in the 1950s when most major transmitter manufacturers began making SSB exciters, led by Central Electronics with its high quality 10A, 10B and 20A exciters, and then with its 100V transmitter (shown above). Unfortunately, Central Electronics was acquired by Zenith Electronics about 1959 and then withdrew from the amateur radio market. That was a major loss, but by then Collins Radio, Hallicrafters, E.F. Johnson and others were also making SSB transmitters (in big boxes).

As Central Electronics was fading from the scene, Collins Radio became the dominant force in the high-end SSB market. Collins had identified military applications for SSB systems but also marketed its products to well-heeled amateurs. Its mechanical filter technology established a new standard of excellence for SSB and the Collins 75A4 receiver/KWS-1 transmitter combination became the station of choice for those who could afford it. Later Collins launched the S-Line with snazzy new styling and top performance.

Collins also popularized the concept of *transceivers*. The KWM-1 represented a new approach to amateur radio—a complete SSB transmitter and receiver in a single compact package with one knob to tune both the transmitter and receiver. Then the KWM-2 arrived with S-Line styling and coverage of all HF bands in one box (the KWM-1 covered only 10, 15 and 20 meters). But for young hams like me in the 1950s, Collins equipment was out of reach.

In 1958, Don Stoner, W6TNS, offered an affordable alternative: double sideband. In his *New Sideband Handbook*, a 1958 CQ publication, he described simple circuits for DSB transmitters with the carrier suppressed but without the filtering required for SSB. I built a DSB transmitter in 1959 and it worked well, but DSB wasn't SSB and I didn't feel welcome in the clubby world of SSB round-tables. I put the DSB rig away and saved up to buy a Heathkit DX-100 for AM phone, which was still where most of the action was in the late 1950s.

As a young ham in the 1950s I operated several contests on AM before SSB became the mainstream voice mode on the HF bands. The high point for me was 1959 Phone Sweepstakes. I finished second in the Los Angeles section at age 16, running a Heathkit DX-100 transmitter (shown at right) and Hallicrafters SX-101 receiver to a 2-element cubical quad for 10 and 15 meters up 25 feet at the center (not very high even by 1959 standards). The guy who beat me (W6LNW) was #2 nationally, using much bigger and higher antennas than mine.

QST published a list of the equipment used by all of the section leaders in those days. In 1959 almost all of the winners were running AM transmitters like Viking Valiants, DX-100s or the earlier Viking I and Viking II rigs, not SSB equipment.

What was contesting like in the AM era? Phone contesting didn't seem all that different back then--except for the awful QRM caused by heterodynes from adjacent AM carriers. With my DX-100 (about 100 watts of high-level plate modulated AM), I could hold a frequency and *run* all day on 10 or 15 (but not 20 or 40). The other alternative was the *search and pounce* operating technique and it was a pain. Without a transceive mode you had to manually zero-beat every station to get on his (or her) frequency before calling.

By the time I returned to contesting after college, things were different. By 1965 almost all of the section leaders listed in QST were running SSB rigs and operating the contest mainly on SSB. At the same time, overall voice activity was increasing dramatically. In 1959 Sweepstakes, CW logs outnumbered phone logs by a 3:1 ratio. By 1965, the ratio of CW logs to phone logs was only 5:4. There were more phone logs than CW logs in SS for the first time in 1970, according to tallies by Ellen White, W1YYM (now W1YL), who wrote most of the SS articles for QST in that era.

I think the key turning point in the popularization of SSB was the introduction of the Swan 120, Swan 140 and Swan 175 transceivers about 1961. These were low-cost single-band transceivers that introduced thousands of hams to SSB. They were far smaller than most previous SSB equipment. In one small box there was a complete transmitter and receiver that offered remarkably good performance for the price and size. Many of us operated mobile with

a Swan single-bander in a car in 1962 or 1963. Herb Johnson, W6QKI, the founder of Swan, had come up with a breakthrough product.

Soon Swan offered the three-band Swan 240, also at a modest price. Then Swan launched the 400, a five-band transceiver. It had an outboard VFO, but it was still compact and affordable. The VFO could be mounted under the dash, with the rig itself in a car trunk. Swan then squeezed the VFO inside a five-band transceiver and launched the Swan 350. That was probably Swan's most successful product and it introduced thousands more hams to SSB. But by then Swan had a lot of competition in the SSB transceiver market. National was making the NCX-3 and NCX-5, while Hallicrafters launched the SR-150 and Heathkit produced the SB-100 as a five-band transceiver kit. Then there was the Galaxy 5 and later models from the successor to Globe Electronics. Drake announced the TR-3 as a five-band transceiver with one KHz dial calibration like the Collins S-Line, but without the Collins price. There was also the mostly-solid-state SBE-33 transceiver. By the time Kenwood announced the TS-520 and Yaesu produced the original FT-101, SSB had arrived.

Perhaps a sign of the changing times came at the 1966 ARRL Southwestern Division Convention. By then AM operators were on the defensive. They were outnumbered and most realized their mode was technically challenged. At the ARRL Forum a group of AM operators asked for the HF bands to be partitioned into separate SSB and AM subbands to protect AM's dwindling turf. The ARRL leadership said a flat "NO." AM has remained a nostalgic favorite ever since, but not the mode you choose to work most contests or chase rare DX. SSB had become mainstream in HF amateur radio, but it took 30 years. As this transition was under way, another technical revolution was happening, of course. The world was moving from vacuum tubes to solid state. That transition was enormously important, but it is a subject for another day.

A similar battle of modes was fought on six and two meters a few years later, but the combatants were mainly AM and FM. At first most amateurs on six and two used AM, as did their HF counterparts. But in the 1960s (in California, at least), technical gurus from the land-mobile community started setting up amateur FM repeaters and remote bases. Once again, they were bringing an established commercial technology to the ham bands. There was a lot of talk about converting surplus Motorola and GE "Pre-prog" (above) or "Progress Line" radios for amateur use. But there was also a rival trend under way. Imported FM radios began to appear in America, supplanting the commercial radios on the ham bands. That led to new turf wars between the barons of land mobile and local radio clubs that saw an FM repeater as a way for their members to stay in touch. Repeater coordination battles flared up

everywhere. AM got lost in that shuffle. Amateurs put their Clegg 99ers, 22ers and even their Clegg Zeus monsters in storage. The mainstream was now occupied by FM. However, weak signal CHF operators moved their niche interest to SSB from AM in the 1960s and 1970s. That move was inevitable once Heathkit, Swan and Drake started making six-meter SSB transceivers and transverters for two. You could buy a Heathkit SB-110, Swan 250 or Drake TR-6 (at right) and work people you never dreamt of working back in AM days.

Now we have still another transition under way. The WSJT-based digital modes are booming in popularity. Not many of us remember when vacuum-tube CW rigs supplanted spark, but some of us did see SSB become mainstream first on HF and then for VHF weak-signal work--while FM was supplanting AM to become mainstream for most other VHF operating. We also saw compact solid state rigs replace vacuum tube "boat anchors" in ham shacks everywhere--even as big vacuum-tube AM transmitters were proudly restored by nostalgic hams worldwide. For us the debate about FT8 brings a sense of deja vu.

Personal computers and the Internet have revolutionized life on Earth in thousands of ways. Amateur radio could never escape this pervasive influence. From worldwide Internet-based remote control of amateur radio stations to software defined radio technology, the digital world has forever changed ham radio. FT8 is one more manifestation of our changing times. Although it is not likely to replace the traditional CW and analog voice modes altogether, it provides a new alternative for long-distance, weak-signal communications.

Wayne Overbeck holds a Ph.D. from UCLA and a J.D. from Loyola Law School. He was first licensed in 1957 and was a professor at California State University, Fullerton from 1968 until 1973 and from 1980 until he retired in 2003. He authored 20 editions of a college textbook, Major Principles of Media Law, and also served four terms as an elected vice director of the American Radio Relay League. See http://n6nb.com

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A postscript: Much historical information about both broadcasting and amateur radio can be found at the California Historical Radio Society's 7,500-square-foot museum in Alameda. The museum has an impressive collection of restored radios in addition to an extensive radio library.