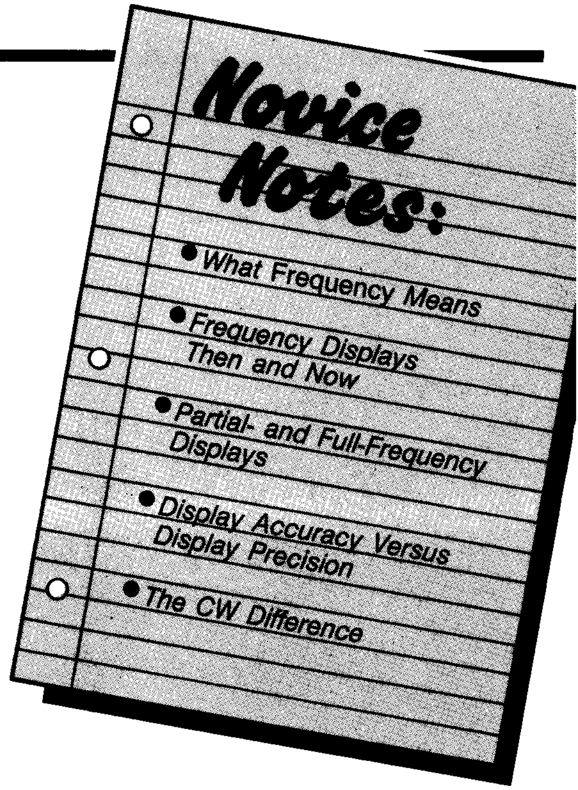
What Your Frequency Display Really Tells You—*Part Two*†



You can't always read your operating frequency directly from your radio's dial or frequency display. Here's how to be sure of what your radio's telling you.

By David Newkirk, WJ1Z
Senior Assistant Technical Editor

"Our radios' frequency displays exist to tell us where our radios are tuned" sounds almost annoyingly self-evident until you realize that "where our radios are tuned" can mean different things under different circumstances. Part 1 of this article explored those circumstances by explaining what your frequency display tells—and *doesn't* tell—about your radio signal. This article shows you how to get the information you need from your radio's frequency display.

"Huh?" you ask. "Most modern radios display frequencies numerically—in actual digits! What's the big deal about understanding *that*?" I answer: (1) The numbers shown on the frequency displays of *even the very latest radios* usually need a little translation before they can be directly equated with frequencies expressed in the FCC Rules; and (2) many radio amateurs use older radios, and *QST* aims to serve them, too. So, here's how to understand the frequency displays you're most likely to encounter in modern radios and popular vintage gear. I won't cover absolutely every variation on How Radios Have Talked Frequency Through the Ages; I'll just hit the major display classes. Your radio's operating manual is the final authority on how to read and calibrate its frequency display.

Remembering What *Frequency* Means

Before we delve into DisplaySpeak, let's be sure we know what our radios' displays are trying to tell us. Radio energy consists of *alternating currents and voltages* that vary smoothly between negative and positive many millions of times per second. Each complete alternation (starting at zero, hitting a maximum of one polarity, falling through zero, hitting a maximum of the opposite polarity and returning to zero) is called a *cycle*. The signal characteristic called *frequency* conveys how many cycles occur in *one second*. We honor radio pioneer Heinrich Hertz by naming the basic unit of frequency (one cycle in one second) the *hertz*.

Such a large number of radio-signal cycles occur during one second that talking about them in terms of hertz (written and spoken the same way, and abbreviated *Hz*, in singular and plural) is pretty clumsy. So, we express radio frequencies in terms of larger units made up of *multiples* of

Cycling Hertz

Before *hertz* was adopted worldwide as the name for *cycles per second*, US radio enthusiasts generally talked frequency in terms of *cycles*, *kilocycles* (kc.), *megacycles* (mc. and, later, Mc.) and *gigacycles* (Gc., predated for a while by *kilomegacycles* [kMc.]). The phrase *per second* often fell off by convention, although some technical folk included it in abbreviations (*cps* or [particularly overseas] *c/s*, *kc/s*, *Mc/s* and *Gc/s*).

Show me a ham who talks about moving down the band "a few kay sees," and I'll show you an old-timer. Show me a ham operating at 80 meters who suggests to a cohort that they go "down to 20," and I'll show you a *really* old-timer—talking wavelength!—*WJ1Z*

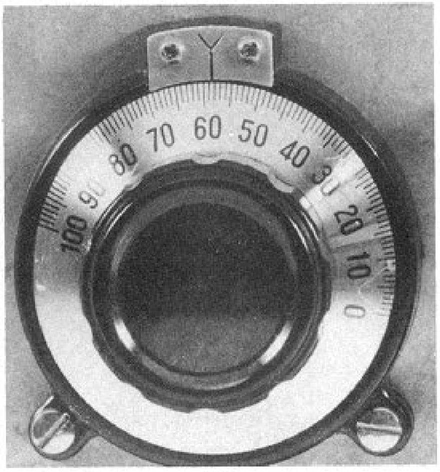
Table 1
Multiples-of-Hertz Frequency Units

Prefix	*Multiple*	*Meaning*
kilo	1,000	1,000 Hz = 1 kilohertz = 1 kHz
mega	1,000,000	1,000,000 Hz = 1 megahertz = 1 MHz
giga	1,000,000,000	1,000,000,000 Hz = 1 gigahertz = 1 GHz

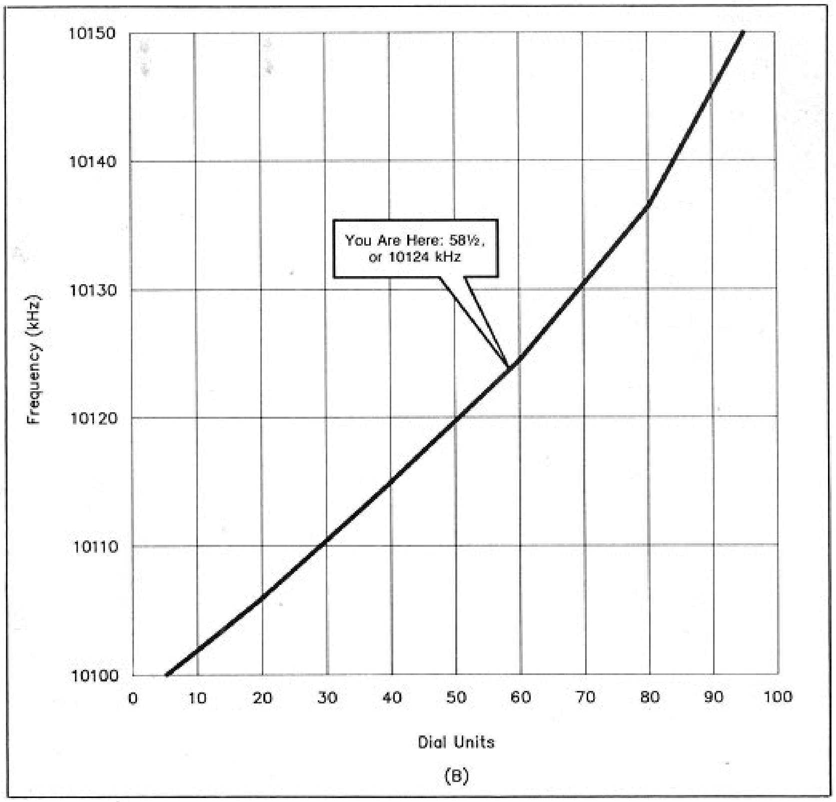
Useful practical equivalents:

10 Hz = 0.01 kHz
100 Hz = 0.1 kHz
1,000 kHz = 1 MHz
1,000 MHz = 1 GHz

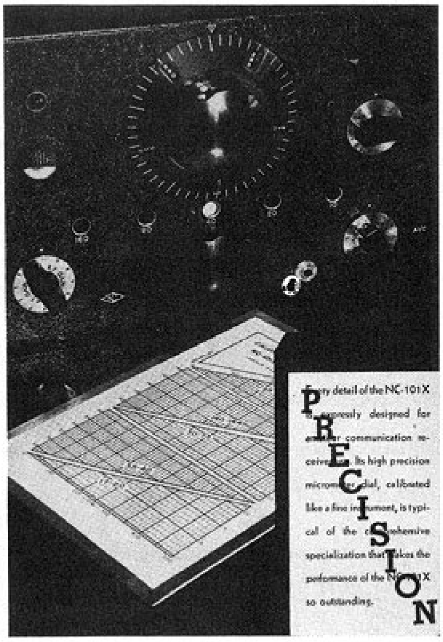
†Part 1 of this article appeared on pages 28-32 of August 1991 *QST*.



(A)



(B)



(C)

Fig 1—The earliest tuning display—a logging scale (A) teamed with a calibration curve (B)—is still used by radio amateurs. You calibrate a radio this way by graphing data points for as many known frequencies as possible throughout the radio's tuning range and connecting them with line segments. (Some logging-scale-calibrated equipment substitutes a frequency-versus-dial look-up table for the graph.) According to the curve at B, the dial at A is set to about 10124 kHz.

National's NC-101X, the first commercial, band-switched ham-bands-only receiver (1937, C), didn't rely on direct frequency readout for its Cadillac reputation. You had to figure out where you'd tuned the radio's ultra-smooth, 500-division "micrometer" dial with the help of calibration curves.

hertz. We name these multiple-of-hertz units with the help of internationally agreed upon prefixes as shown in Table 1.

Now that we've reviewed the message our frequency displays send, let's look at how they send it.

Logging Scale and Calibration Curve

Many ham experimenters and home-made-equipment tinkerers still use this tuning-display method (Fig 1). A radio calibrated this way sports a tuning dial with a linear numeric scale—0 to 100 is common (Fig 1A). A calibration curve equates the scale's numbers with frequency units (Fig 1B). Some of the classiest commercial ham receivers had logging-scale-and-calibration-curve frequency displays before direct frequency displays came in (Fig 1C).

Mechanical Direct Frequency Readouts

By the late 1930s, radio tuning and manufacturing techniques evolved to allow tuning ranges to be adjusted on a production line to agree with preprinted frequency scales. Direct frequency calibration has been with us ever since in many forms. Here's a look at some common mechanical forms of direct frequency display. Remember, all of them have one thing in common: They equate the physical position of something—usually a tuning-dial pointer or switch knob—with frequency.

Calibrated Circular and Slide-Rule Dials

Draw a line, calibrate it in frequency and then move it relative to a pointer, and you've got a direct mechanical frequency display (Fig 2). Many such displays were circular on ham equipment; the straight-line version, hyped as the *slide-rule* dial, survives today in consumer electronics equipment (and, in electronic form, as an adjunct to direct numeric display in some high-end ham transceivers!).

Cyclometers and Thumbwheel Switches

Many consumer tape players and recorders include belt-driven mechanical counters that indicate tape travel from 0 to 999 or 9999. These devices, which consist of sets of rotating rings, one ring per counter digit, are called *cyclometers*. A few amateur radios have employed cyclometer frequency readouts through the years, but such readouts were more common on military equipment.

Related to the cyclometer, and far more common (mainly in VHF and UHF hand-helds before the advent of keypad tuning in such radios), were *thumbwheel switches* (Fig 3). Thumbwheel switches combine frequency display and control: You turn each thumbwheel individually to set that digit of the radio's frequency.

Rare is the thumbwheel-tuned radio that

Fig 2—Just as World War II began, *direct* frequency calibration became a hot selling point even on lower-priced, general-coverage receivers like the Hallicrafters SX-24 (1939). This *QST* advertisement shows the *bandspread* dial of a "two-dial" radio design (main tuning or *bandset*, plus bandspread): You set the main-tuning knob just so for each bandspread range, and then tune with the bandspread.

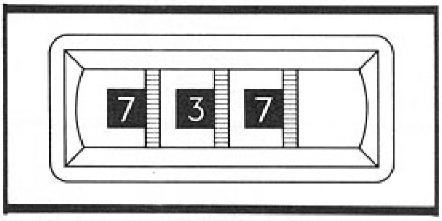


Fig 3—*Thumbwheels* combine frequency control with frequency display: Turning a thumbwheel to display a digit also tunes that digit of the radio's operating frequency. Displayed on a 2-m radio, these digits would indicate a tuned frequency of 147.37 MHz; you mentally supply the leading *1* and *4*. Radios tuned like this usually include a +5 kHz switch to let you get to 5-kHz increments between the 10-kHz steps allowed by the rightmost thumbwheel.

Accuracy Versus Precision

Display *accuracy* relates to *how correct* a radio's displayed frequency is. Display *precision* relates to *how finely* a radio displays frequencies. It's important not to confuse the two concepts with each other, because they're really quite different. High display *accuracy* helps keep you legal by giving you solid information on where you're really tuned. High display *precision* lets you make good use of that accuracy through fine tuning.

A highly precise display is not *necessarily* highly accurate. The widespread presence of electronic direct numerical ("digital") displays on everything from ham rigs to bathroom scales tempts us to ascribe accuracy unduly and assume precision inappropriately. A frequency display that indicates frequencies in 10-Hz steps can mislead you if the frequency it displays is inaccurate by a kilohertz or two. A digital bathroom scale that displays weight in half-ounce steps is a joke if you can't get it to repeat a given measurement to within the same quarter of a pound—especially if the weights it displays are all a half pound too high anyway!

The NC-101X receiver shown in Fig 1C is an example of how frequency-display precision can outrun accuracy. Although the '101X's 500-division dial can be reset to within ½ division in 500, National acknowledged manufacturing tolerances and the frequency drift common in radios of those days by recommending that the NC-101X not be recalibrated unless its calibration curve and tuning dial disagreed by more than *20 dial divisions*—more than 20 kHz at 3.5 MHz per the NC-101X's calibration. That's an error of more than 5.7 kHz per megahertz! Frequency displays on modern radios are typically light years more accurate—to within 10 Hz per megahertz or so.

When we enjoy vintage gear, we need to be careful not to ascribe digital precision to systems that can't provide it. The Fig 4 caption says that the 75S-3 dial reading shown equates to 21345½ kHz. Why didn't I say *21345.5* instead, when ½ arithmetically equals 0.5? Because *21345.5* implies that the 75S-3 dial displays frequencies to a precision of 0.1 kHz, which it cannot. (The dial's hairline indicator alone looks to be a tenth of a kilohertz wide. Also, how closely did I calibrate that radio at the nearest marker-signal point? How far off is the dial calibration by the time I tune it that far from the nearest calibration point? And how accurate is that calibration oscillator, anyway?)

Frequency accuracy versus frequency precision: Let's get them straight, keep them straight, and call our frequencies as our radios really allow us to see them.—*WJ1Z*

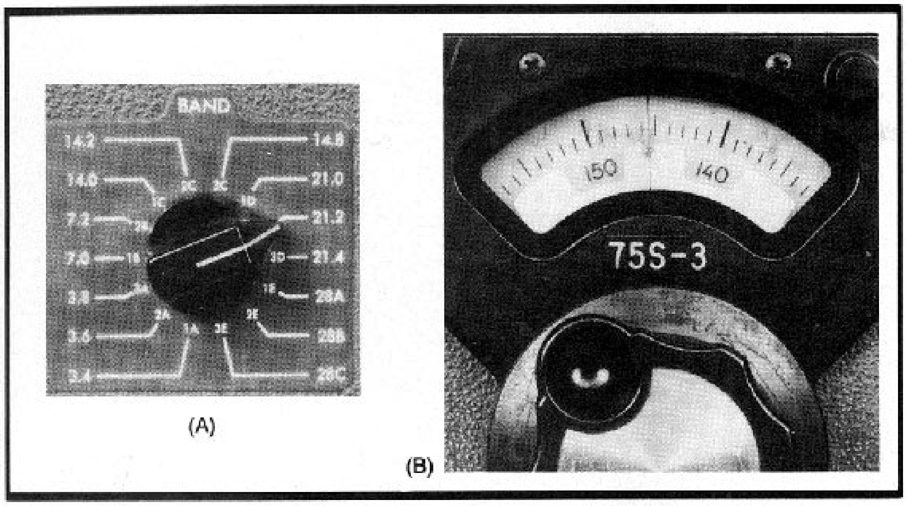
Does It Matter That Your Radio's Frequency Display Isn't a Frequency *Counter*?

Considering the frequency readouts on modern, microprocessor-controlled transceivers, some longtime radio amateurs grouch: "Yeah, but see that digital display? It doesn't *count* anything! It only displays what it's told to. Give me a digital display that's a frequency *counter*!" And you may wonder if you should worry about this.

I admit it: *I* moaned and complained about command-driven, as opposed to counter-driven, frequency displays when they first hit the market. "After all," I reasoned, "a command-driven display may screw me up because it won't tell me if its radio's oscillators unwantedly drift or shift." Then I realized that a frequency counter is only as accurate as its time-base oscillator. And a time-base oscillator can drift or shift without our necessarily knowing the difference. So, like command-driven frequency displays, counter-based displays are only as accurate as their reference oscillators allow.

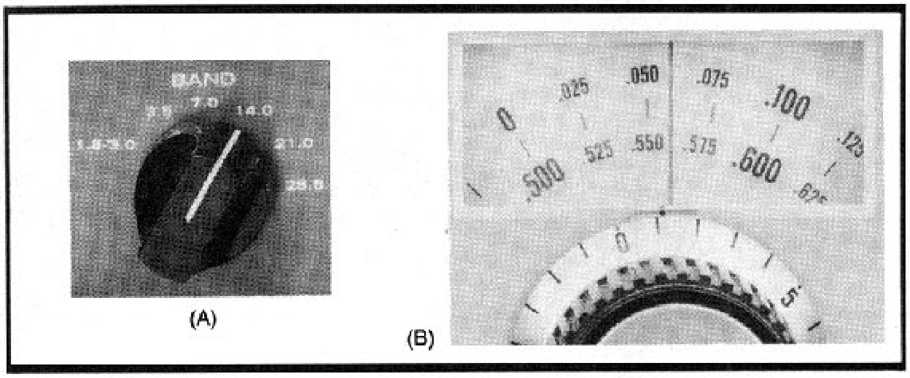
Today's command-driven digital displays are modern equivalents to the mechanical frequency readouts on most vintage radios. They display what they display regardless of what the frequency-determining innards of the radio do. Hams have plenty of experience with such gear. Anything commercial or homemade that was calibrated with a logging scale and frequency-versus-dial graph, Drake 2 and 4 lines, Collins S lines, Hallicrafterses, Hammarlunds, Nationals, RMEs, most Swans, and early Yaesus and Kenwoods—*all* had mechanical (in effect, command-driven) frequency readouts corruptible by drift, instability and misalignment in their electronics. Sure, you could recalibrate such radios—just as you can recalibrate a modern radio if it drifts out of spec. The difference is that modern radios generally resolve frequencies more finely, drift less and require recalibration much less often.—*WJ1Z*

allows *complete* frequency control/display by thumbwheel. As applied on, say, a 2-m radio, thumbwheels display, and allow adjustment of, only the digits *7, 3* and *7*—megahertz, and hundreds and tens of kilohertz—in the frequency 147.375 MHz. *You* have to keep in mind that the radio tunes in the 140-MHz region and mentally supply the first two frequency digits; a switch (labeled something like +5 kHz) is usually available for tuning the 5-kHz steps between the 10-kHz jumps adjustable via thumbwheel. (Comprehending where you're transmitting with such a radio involves even more mental gymnastics if you've set the radio to operate at a repeater *split*—that is, if you've set it to receive on



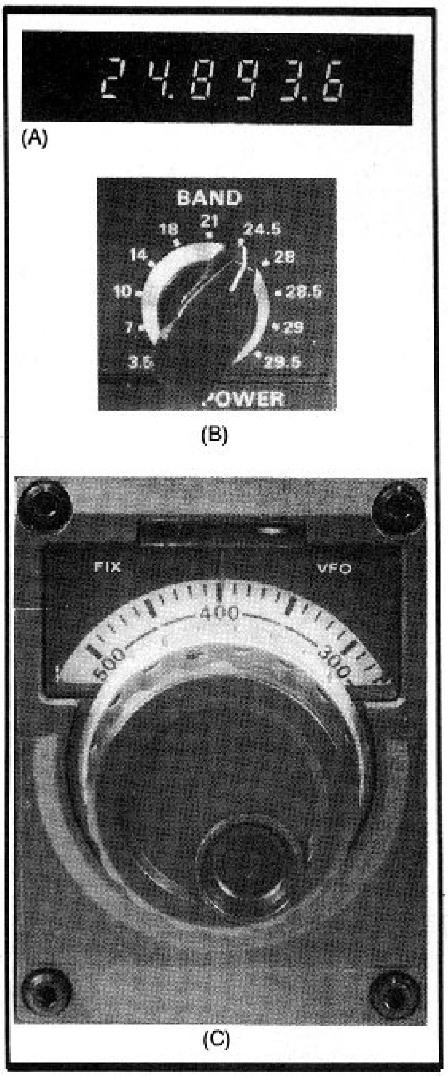
(A)
(B)

Fig 4—Reading your operating frequency on a Collins 75S-3 receiver involves adding the megahertz indicated by its **BAND** switch (A) to the kilohertz shown on its tuning dial (B). This 75S-3 is tuned to 21345½ kHz. The small knob at the upper-right corner of the tuning-dial escutcheon allows side-to-side adjustment of the tuning-dial indicator (fiducial) line. (The 75S-3 and most similar receivers and transceivers facilitate such adjustment by providing a switchable *marker* or *calibrator* oscillator that generates signals at regular intervals [25, 50 or 100 kHz] across the dial.)



(A)
(B)

Fig 5—Some radios' frequency displays require that you add information from *three* sources: a **BAND** switch (A) and two tuning dials (B). This radio's coarse tuning dial is calibrated in 25-kHz steps from 0 to 0.500 and 0.500 to 1.000 to help you calculate frequencies in bands with lower edges that end with .5—3.5 MHz, for example. The R. L. Drake T-4XB transmitter behind these controls is tuned to about 14051-1/5 kHz. Later Drake "4-line" gear included superimposed fine and coarse dials and dispensed with a calibrated dial skirt.



(A)
(B)
(C)

Fig 6—Mechanical and digital frequency displays appeared simultaneously on radios that straddled the 1970s and 1980s as hams got used to the idea of trusting frequency display entirely to electronics. This transceiver includes a counter-based digital display (A) precise to 0.1 kHz (100 Hz) and an additive mechanical frequency display (B and C) similar to that shown in Fig 5. Some digital frequency displays from this era may confuse you by indicating different frequencies in CW receive and transmit. The sidebar "When All Else Fails, Think Transmit" in Part 1 of this article suggests an antidote; this month's "CW-Receive Frequency Display" sidebar discusses differences between CW-receive display then and now.

one frequency and transmit on another.)

Additive Frequency Displays

I call frequency displays like the one I just described *additive* because they require you to add information from several sources—from two or more mechanical controls, and sometimes your own memory—to determine your operating frequency. Although this sounds complicated, it's pretty easy once you develop the knack. Just ask any ham who used (or still uses) any of the many vintage MF/HF ham radios that use *even more complicated* additive, mechanical frequency displays—rigs from Collins, Drake, Heathkit, Kenwood, Swan, Ten-Tec, Yaesu and others. Such radios are still popular and available, so let's see how *they* talk frequency.

Band Switch + Dial + (Sometimes) Dial Skirt

Two-dial, general-coverage-and-ham-bandspread receivers generally tune faster—more kilohertz per dial rotation—as they tune higher in frequency. Relatedly, they also generally *work less well* as you tune them higher in frequency. The end came nearer for such radios when, beginning in the 1940s, the Collins Radio Company developed military and ham radios that tuned at the same rate, and offered generally uniform performance, throughout their tuning ranges. Over time, other MF/HF radio manufacturers adopted similar equipment designs—including frequency-display approaches that require you to add information from a band switch and tuning dial (Fig 4).

One variation on this scheme (Fig 5) requires that you add information from the **BAND** switch and *two* tuning dials—one that indicates frequency relatively coarsely and another (usually the tuning-dial skirt itself) that indicates kilohertz.

Received-CW Frequency Display

CW is the only aurally received mode in which we intentionally *don't* recover the original modulating information in its electronic form (the *baseband* signal) from the received *radio* signal. During CW transmission, baseband CW exists merely as a dc voltage that varies between two levels (usually 0, or very near it, at key down, to a few volts at key up). This voltage variation turns our transmitter on and off. The resulting transmitted CW signal consists of a radio carrier that comes on at the beginning of each dot and dash, stays on *during* each dot or dash, and goes off at the end of each dot and dash. In Part 1, I said that this process also generates *keying sidebands* above and below the carrier. And that's so—but now I clarify that those keying sidebands occur *only at the signal's on and off transitions*. Here's where the big difference between CW and most other modes comes in. In modes like AM, SSB and FM, the information in the sidebands, and *only* in the sidebands, is the information we want to come out of our receivers. The absence or presence of the carrier contributes nothing to this information. CW is another story. In CW, the absence or presence of the carrier, and the relative duration of those absences and presences, form dots and dashes. The keying sidebands (which, on their own, sound like clicks or thumps) are also important in aural CW reception: They help our brains be sure of exactly when the carrier appears and disappears. Because of this, we need to tune our radios so we can hear the sidebands *and* the carrier during CW reception.

This fact requires equipment designers to address a fundamental question: Should a radio's frequency display indicate the carrier frequency of incoming CW signals when the radio is tuned to hear *just the keying sidebands*—a nearly meaningless series of thumps and clicks—or when the radio is tuned to hear the keying sidebands *and* the carrier, with the carrier audible at a useful and comfortable pitch? Luckily, ham-equipment designers generally seem to have taken advantage of microprocessor control to make our radios display received-CW *carrier* frequencies when we tune them to receive CW carriers *and* sidebands, with the carrier generating a useful pitch.

But such systems require you to tune incoming CW signals to generate a predetermined pitch if you want your radio to accurately display each signal's actual carrier frequency. (Your radio's operating manual probably tells you this pitch in hertz. To find out what that pitch sounds like, set your radio for CW and tune it to, say, *exactly* 10.00000 MHz [or 7.335000 MHz if your radio receives CHU but not WWV/WWVH]. You'll hear WWV/WWVH's or CHU's carrier as an audio tone. *That's* the pitch you'll hear when you tune in CW signals correctly with the radio.) Bonus: Tuning in CW signals at the correct pitch also puts your transceiver's transmitter on the incoming signal's frequency.

Possible snag for transition-rig owners: A counter-based-display radio may correctly indicate the incoming signal's carrier frequency only when you tune it "to zero beat"—at which point you hear CW only as thumpy keying sidebands. (Such radios usually also display different frequencies in CW transmit and receive.) Caution: with such a radio, you'll almost certainly have to tune in that same signal to produce your radio's proper receiving pitch—usually 700 to 800 Hz—to put its transmitter on the same frequency as the incoming signal. Thus, determining a received CW signal's carrier frequency *and* putting your transceiver transmitter on that frequency is more complicated with most transition, counter-based-display transceivers than with modern radios.

A CW signal's carrier frequency is the frequency we need to display during CW transmission *and* reception. Modern radios do us the favor of displaying CW carrier frequency when we've tuned away from zero beat far enough to hear a signal's carrier *and* keying sidebands at a predetermined usable pitch—as we *must* do during practical aural CW reception. Displaying received CW signals' true carrier frequencies "at zero beat"—that is, when all we can hear are the cryptic thumps and bangs of keying sidebands—is a convention whose time has, thankfully, gone.—*WJ1Z*

Fig 7—Many transceivers display full operating frequencies precise to 0.1 kHz (100 Hz) or (especially in MF/HF rigs) 0.01 kHz (10 Hz), with one standard quirk: They include *two* decimal points. So—does this display say 18.15286 MHz, or does it say 18,152.86 kHz? Answer: Both! I like to think of such readouts as *megakilohertz* displays because they allow us to read and think of displayed frequencies in terms of megahertz and kilohertz with equal facility, even simultaneously. And that can be helpful, because we intuitively shift our mental frequency precision from megahertz (when changing bands) to kilohertz (when bandscanning and setting up splits) to changes of only a few tens of hertz (when fine-tuning signals from CW, SSB and keyboard modes).

You-Calibrate-It Switches and Buttons

Before the widespread presence of frequency synthesis in VHF and UHF transceivers, you had to buy a crystal (or two, for repeater splits) for each communication channel you wanted to use. You accessed these channels via push-button or rotary switch—switches you could sometimes calibrate by penciling in the frequency or frequencies that corresponded to each switch position. Many such rigs serve well today as dedicated packet transceivers, and they're sometimes available inexpensively at hamfests. Everything's simple and fine until the labels fall off or you lose the channel-versus-frequency chart; then you have to calculate the radio's operating frequency on the basis of crystal frequencies and operating-manual information, and/or transmit into a dummy antenna and "sniff" enough RF to get a reading on a frequency counter.

Digital Frequency Readouts

Nowadays, of course, digital—that is, electronic direct numeric—displays are standard on most Amateur Radio transceivers. This didn't happen overnight, though: Some manufacturers weaned hams from additive mechanical displays by building mechanical *and* digital displays into radios that straddled the 1970s and 1980s (Fig 6). Some manufacturers briefly adopted hybrid displays that require you to add digital kilohertz information to megahertz information indicated on a mechanical band switch. And some manufacturers offered add-on or retrofit digital displays as options on equipment with mechanical displays.

The advent of step-tuned, microprocessor-controlled transceivers brought us the digital frequency displays we know today (Fig 7)—displays that generally indicate

- the entire operating frequency, precise to 0.1 kHz (100 Hz) or 0.01 kHz (10 Hz)
- what they're commanded to by their radios' microprocessors—not the output of frequency counters like transition rigs of the 1970s and early 1980s
- where applicable, their radios' actual

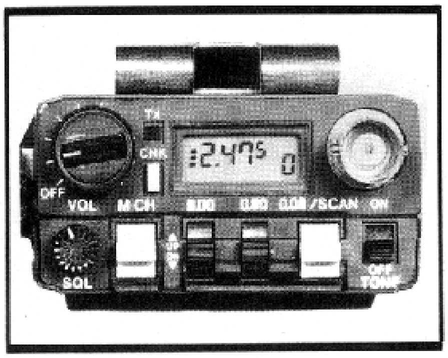


Fig 8—Partial-frequency digital displays employ a number of tricks to convey operating-frequency digits space doesn't allow them to show. Each additional square dot at the left of this liquid-crystal display adds 10 MHz to the displayed frequency, with one (the lowermost) dot equalling 140 MHz. This 2-m hand-held is tuned to receive NOAA weather at 162.475 MHz. The lower-right *0* indicates that Memory 0 is in use. As with many additive frequency displays, these numbers make little sense unless the operator remembers how to augment and process the information shown.

CW-transmit frequencies in CW mode, *even during receive*

Entire-frequency display is standard now in MF/HF rigs and moving toward standard in VHF/UHF rigs as display and component densities increase and manufacturing techniques improve. Short of this, some radios maximize the information conveyable by tiny displays with the help of cryptic annunciators (Fig 8) or omit (and/or downsize) leading megahertz digits (Fig 9).

Fig 9—Transceivers intended for mobile use include frequency displays optimized for at-a-glance reading. The inclusion of hundreds- and tens-of-megahertz digits on radios like this is a relatively recent innovation—a welcome innovation, too, since a full-frequency display can help you explain to a nonham law-enforcement official that your radio is *not* a scanner set up to receive public-service transmissions.

Some hams dislike the fact that modern digital frequency displays aren't counter-based; they believe that digital displays must be counter-based to be trustable. Don't be one of them! See the sidebar "Does It Matter That Your Radio's Frequency Display Isn't a Frequency *Counter?*"

Hams, ham-equipment designers and ham-equipment-manual writers don't always agree on how our radios display (or *should* display) frequency during CW reception. This disagreement leads to the sort of confusion I hoped to end-run with the "If All Else Fails, Think Transmit" sidebar in Part 1 of this article. Talking hardware this month, I prefer to meet that subject head-on. See "Received-CW Frequency Display" for more on CW-frequency-display fact and fallacy.

A Frequency Computer in Every Shack: You

This overview of frequency-display hardware cannot take the place of you taking the time to understand how your radio displays frequencies. That means spending time with your radio and its operating manual and learning how the three of you interact! Despite the considerable evolution in frequency-display technology throughout nearly a century of Amateur Radio progress, frequency displays do little more now than they did then: They merely provide you with a few numbers about your signal's characteristic frequency—in most cases, your carrier frequency; sometimes, your *mark* frequency. *Your* role in keeping your operation on frequency is as important now as it was when Amateur Radio was young. QST

New Books

BUILDING POWER SUPPLIES

By David Lines, Radio Shack/Archer cat. no. 276-5025. Developed and published by Master Publishing Inc. 92 pp, illustrated with black & white drawings and diagrams. Softcover, 6 × 9 inches, $4.95 retail.

Reviewed by Mike Gruber, WA1SVF ARRL Laboratory Engineer

Power supplies, often taken for granted by seasoned experimenters and sometimes misunderstood by beginners, always seem to be in short supply around an electronics workshop. The rule of thumb, at least in my shack, is that you can never have too many power supplies. Building your own makes good sense. Parts are easy to obtain and most power supply projects aren't too ambitious, even for a beginner. Power-supply construction can be fun and educational, save you money and provide a complement to your test bench.

Building Power Supplies takes you from the fundamentals of electrical power to the construction of switching regulators in seven chapters. The progression of the theory is logical and easy to follow. Beginners should have no difficulty understanding the technical presentation. Although not quite sufficient for the reader to design his or her own power supplies, the discussion is well suited to complement the book's construction projects. If you're an experienced electronics enthusiast, you may find yourself skimming or skipping parts of this text in favor of the chapters detailing the construction projects.

The projects selected for this book feature common power requirements. The designs aren't particularly exotic, but they're straightforward and use readily available parts, all of which are available from Radio Shack (surprise!). Radio Shack part numbers are included. The instructions are detailed in easy-to-follow step-by-step procedures, drawings and photographs. Perf board and point-to-point wiring techniques are used; printed circuit board details, such as artwork, aren't included.

The linear and switching power supply construction chapters are complemented by a preceding "How it Works" chapter. This material is well presented and clear. Lines does a nice job of enhancing the beginner's understanding and appreciation of each construction project. This insight is invaluable should troubleshooting be required upon completion of the project. Further troubleshooting tips are covered in the final chapter.

The Projects

Five dc power supply projects are included in this book:

1) Linear +5 V, 1 A
2) Linear ± 12 V, 1.5 A per output
3) Linear 3.0-30 V variable
4) Switching +12 V to +5 V step-down converter, 1.5 A
5) Switching +12 V to +24 V step-up converter, 1.5 A

Note: An ac-dc switching power supply is not included in this book.

The weakest point in the construction project design is the use of three 1-A Schottky diodes in parallel. This technique is used to produce a 3-A current rating for the catch diodes in the switching regulators. Any imbalance in these diodes would cause one diode to conduct more heavily than the others. The net result could be a failure at something less than the expected 3 A. Fortunately, the peak current seen by these diodes is less than 3 A and, therefore, they are probably adequate. If a problem is encountered with these diodes, however, it would be an easy task to substitute a larger single diode.

Conclusion

Lines' stated objective in *Building Power Supplies* is twofold: (1) He helps the reader understand the inner workings of various types of power supplies and (2) he shows you how to build useful, working power supplies. To this end, Lines has met his objective. These are workable projects, useful on the bench or in the shack, that look like a lot of fun to build. This book is recommended for anyone, especially a beginner, interested in building or learning more about power supplies.