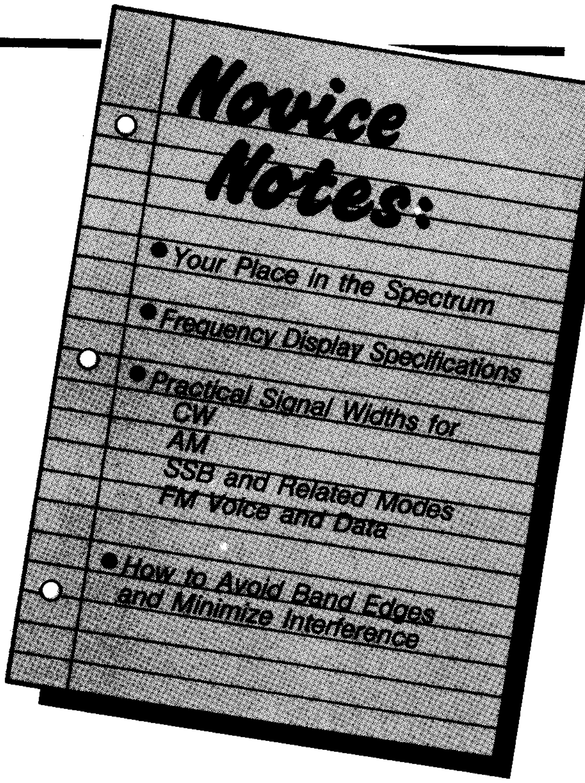
What Your Frequency Display Really Tells You



How close to a band edge can you operate? What your radio's frequency display *doesn't* tell you may be more important than what it does!

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Judging by the size of our radios' tuning knobs and frequency displays relative to other front-panel features, frequency must be pretty important. And it is. If you operate at the wrong frequency, other stations may not hear you, you may cause harmful interference, or you may violate the frequency privileges of your license class.

Assuming that your transceiver is functioning normally, operating at the wrong frequency can be as easy as operating on the *right* frequency. This is so because

1. You may misread, or otherwise be unsure of, what your transceiver's various indicators mean.
2. Your transceiver may be capable of transmission on frequencies other than those authorized by your license—frequencies just a flick of the tuning knob away.
3. You may mistakenly operate using a mode or power not authorized for a frequency otherwise allowed by your license.
4. Your signal, or part of your signal, may fall on an unauthorized frequency even though your license allows you access to the frequency shown on your radio's display.

As a licensed ham, you're responsible for seeing that these things—*all* of these things—don't happen. That's not news to you, I hope! We all occasionally make mistakes connected with Reasons 1 through 3; these we can usually attribute to honest error or confusion. We avoid such mistakes through learning, experience and attention.

But *this* may be news: Off-frequency operation attributable to Reason 4 occurs because many hams do not understand that the radio feature most important in keeping you on frequency—your radio's frequency display—*doesn't* tell you everything you need to know about choosing an acceptable frequency! And your radio's operating manual probably doesn't fill in the gaps, either. So, *QST* to the rescue! This article shows you how to be frequency-conscious whenever you go on the air.

As you read, please keep in mind that FCC-rule brevity, and variations in equipment performance and how you use your equipment, may make it impossible for me to give you specific numbers about how wide your signal can be or how close you can or can't go to a given frequency or band edge. Whenever I can't give you hard numbers, I'll tell you—and I'll tell you why.

You Are Here

Becoming frequency-conscious is almost as easy as locating a particular store at an unfamiliar shopping mall. You stride into the mall and make a beeline for the store directory. The directory kiosk displays a mall map and lists stores by type. Each store listing includes a number. Having found a listing for your store—say, *599 Shops*—you scan the mall map for that number. Got it! Okay, but before you sneaker-squeak off to the store, you do two more things: You scan the map to find your position in the mall—*You Are Here*—and mentally chart your course from Here to There. And then off you go.

You go through a similar process when changing frequency with your Amateur Radio transceiver. Seeking to contact a friend at 14205.48 kilohertz—just one of many possible places to go in the cosmic shopping mall called The Electromagnetic Spectrum—you check your radio's frequency display to find your current position in that spectrum (say, 7201.25 kilohertz), mentally chart your course from Here to There, and take off.

Nowadays, of course, you're as likely to jump to your target frequency via keypad as you are to spin your radio's tuning knob from 7201.25 to 14205.48, but the process is the same. The radio spectrum is like a large *space* that encompasses many possible *places* to be (particular frequencies). Your radio's frequency display serves as a constant, real-time *You Are Here* marker to show you your *position* in that spectrum (Fig 1). Your radio's tuning knob (or **UP** and **DOWN** buttons, or keypad), like your feet, gets you from one frequency place to another.

But hold on. Your radio's frequency display and a store-directory-kiosk *You Are Here* marker share an important similarity: *They indicate your position but not your width.* And width is important! If you don't account for your body width as you walk through a mall, you'll make a lot of people (including you) sore. You'll run into walls, railings and people. If you don't account for your radio signal's width when you operate at the frequency shown on your radio's display, you may unknowingly interfere with other amateurs or even transmit outside an amateur band!

You Stretch from Here to There

Whenever you use a radio signal to do something useful—that is, whenever you use radio to send information (code, voice, data, control signals, a picture—whatever), you *modulate* it (electronically add information to it) by changing its characteristics over

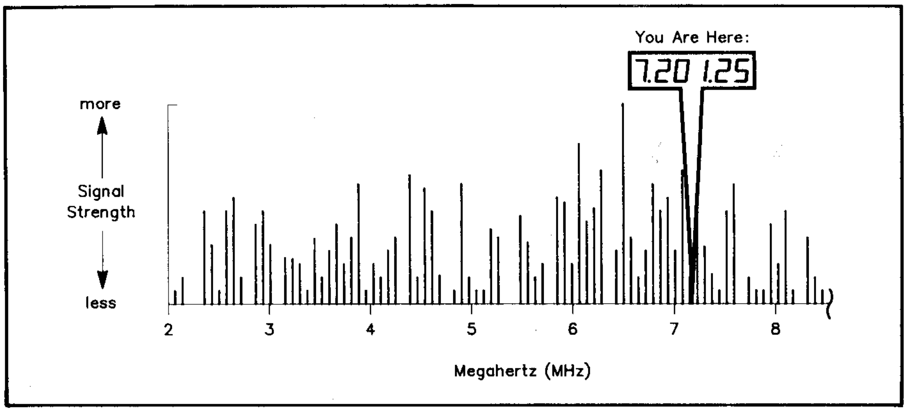

Fig 1—You can view the electromagnetic spectrum like a landscape if you think of it in terms of signal strength (vertical axis) and frequency (horizontal axis). Your radio's frequency readout tells you your signal's *position* in that landscape. (Instruments capable of picturing the radio spectrum like this—*spectrum analyzers*—are common in radio laboratories and repair shops. The ARRL Lab uses one for Product Review testing, as shown by the photos on page 43 of July 1991 *QST*.)

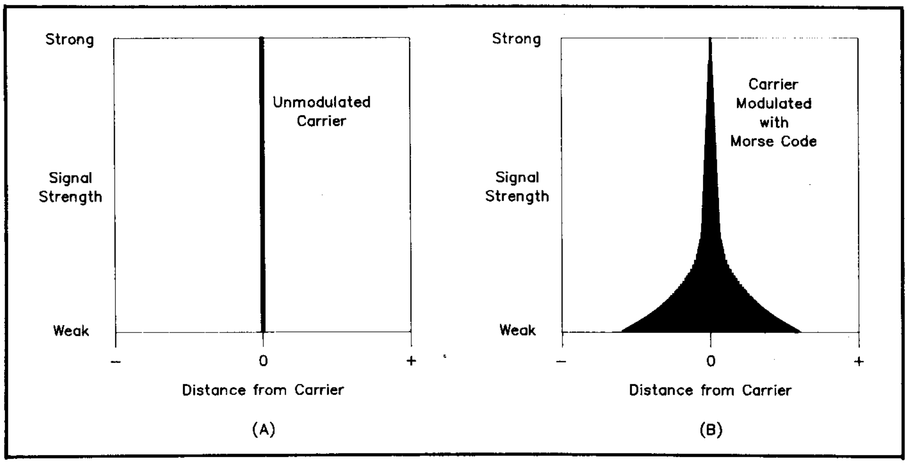

Fig 2—In theory, an unmodulated carrier in the radio spectrum (A) is like a point on a line: It has position but no width. (*Real* radio carriers are always modulated to some extent by frequency drift, propagation, noise, power-supply hum and other factors; this straight line represents an unrealizable ideal.) Modulating a carrier (that is, turning it on and off, or *keying* it) to transmit Morse code (B) generates *sidebands* that widen the signal compared to the unmodulated carrier. The sideband lower in frequency than the carrier is called the *lower sideband* (*LSB*); the sideband higher than the carrier is the *upper sideband* (*USB*). Wider-than-necessary keying sidebands are called *key clicks*. Both keying sidebands must stay on frequencies your license allows you to use.

Read the Manual

Some current transceivers offer you the option of selecting whether your frequency display indicates *mark* or the suppressed-carrier frequency. Some current transceivers include more than one frequency display for sub-receivers or multiple VFOs, and this may confuse you if you operate split or jump between memories or VFOs. How can you figure all this out? What does your radio's manufacturer have to say about how to use its frequency display, anyway? *Read the operating manual* and practice setting your rig's controls according to its instructions. Don't let your rig operate *you*.—*WJ1Z*

time. Doing so widens the signal (Fig 2) compared to its unmodulated state because *sidebands* containing that information appear on both sides of the carrier.

What Your Frequency Display Doesn't Tell You

Your radio's frequency display tells you nothing about how wide your signal gets with modulation. This can lead you to operate illegally even though your transceiver is working right, and even though your license allows you access to the frequency shown on your radio's display.

What Your Frequency Display *Does* Tell You

Unless your radio's instruction manual states otherwise, your radio's frequency display probably indicates only your carrier *frequency—even in suppressed-carrier modes like SSB.* Because of this, you absolutely *must* know something of your sidebands' width and their position relative to your carrier. You need to know this to be sure your sideband or sidebands don't fall out-of-band when you operate close to a band edge. You also need to know this to keep from interfering with other amateurs.

Once you've gotten an idea of how wide your signal is, you need to know one more hardware-dependent thing before using your frequency display to set an operating frequency. *You need to know your radio's frequency-display accuracy.* See the sidebar, "Finding Your Radio's Frequency-Display Accuracy."

Before we explore how wide your signal gets and where its sidebands fall relative to its carrier when you operate CW, AM, SSB, FM, data (including packet), RTTY and AMTOR, you need to understand why I can't give you solid numbers for a lot of this stuff. See the sidebar "FCC and Necessary Signal Bandwidth."

CW

CW signal width. As shown in Fig 2B, keying your carrier on and off produces identical keying sidebands on both sides of the carrier. *How far those sidebands extend depends on the transmitter's keying rise and fall times, not on how many words per minute you send.* (Overdriving your rig's final or an external amplifier can make your signal even wider.) If your transmitter's CW rise and fall times are 5 milliseconds, your signal is about 150 hertz wide. (This and other numbers in this article that refer to CW-signal bandwidth convey *necessary bandwidth* as calculated per §2.202 of the FCC Rules. Equation 11 on page 9-8 of the 1991 *ARRL Handbook for Radio Amateurs* shows the formula used, which also provided the CW-bandwidth numbers shown on page 9-2 of ARRL's *FCC Rule Book*, 8th edition, 4th printing.) If its rise and fall times are 2 milliseconds (fairly typical of commercial transceivers), your signal's bandwidth is about 375 hertz. (If *QST* Product Reviewed your transceiver, you may be able to get a closer approximation of your transceiver model's keying rise and fall times from the keying oscillogram contained in the review.)

How close you may be able to go to a band edge: Half of your signal's bandwidth, plus your transceiver's maximum display error. *In this example,* if your transceiver has a maximum display error of 300 hertz and emits a CW signal 375 hertz wide, you might conclude that you can go no closer to a band edge than 487.5 hertz (300 + ½ of 375 [187.5]).

But your radio may *display* frequencies less precisely than it can *tune* them. In other words, you may be able to tune your radio a few hertz or tens of hertz before its display actually indicates that change. Because of this, I recommend that you take this into account when you choose your operating frequency. To do this, tune your transceiver no closer to the band edge than its maximum display error + half of your bandwidth + the next display increment farther from the edge. *In this example,* that's 500 hertz for a transceiver that displays frequencies to the nearest 100 hertz (0.1 kilohertz) or 490 hertz for a transceiver that displays frequencies to the nearest 10 hertz (0.01 kilohertz).

AM

AM signal width. As with CW, amplitude-modulating your carrier produces identical sidebands on both sides of the carrier. *How far those sidebands extend depends on the highest modulating frequency the transmitter signals can handle* (300-3000 hertz is a longtime convention). (Overmodulating your carrier or overdriving an external amplifier can make your signal even wider.) If your transmitter can reproduce audio up to 3000 hertz (3 kilohertz), your signal is about 6000 hertz (3000 + 3000) wide because it has two sidebands.

How close to a band edge you can operate AM: Your transceiver's maximum display error (example: 300 Hz) + half of your bandwidth + the next display increment farther from the edge. *In this example,* that's 3400 hertz for a transceiver that displays frequencies to the nearest 100 hertz (0.1 kilohertz) or 3310 hertz for a transceiver that displays frequencies to the nearest 10 hertz (0.01 kilohertz).

SSB

SSB signal width. An SSB signal consists of an AM signal with the carrier and one sideband suppressed (Fig 4). If your transmitter's audio circuitry passes signals from 300-3000 hertz (a longtime convention), your signal will be at least 2700 hertz (2.7 kilohertz) wide. (Overdriving your transceiver's final or an external amplifier can make your signal even wider.)

How close you may be able to go to a band edge depends on where your suppressed carrier is compared to the band

FCC and Necessary Signal Bandwidth

I wish this article could consist of nothing other than a list of rock-solid statements like "On CW, don't operate any closer to band edge X than Y hertz"—but it can't. I can't give you hard numbers about exactly how wide your signal is, or exactly how close to a band edge you can play, because (1) I don't know exactly how your equipment performs and (2) Part 97 of the FCC Rules—FCC's rules regulating Amateur Radio—only goes so far in specifying signal characteristics.

Currently, any Part 97 search for this information always ends in hazy, hedgy phrases like "good engineering practice," "to the greatest extent practicable" or "communications-quality A3E emission." FCC hedges on signal width and purity because it must: Even internationally agreed-upon formulas for necessary bandwidth include fudge factors! (The FCC rules include those formulas in §2.202, Bandwidths; Chapter 9 of *The ARRL Handbook for Radio Amateurs*, Modulation and Demodulation, takes you through a number of such calculations step by step.) The fudge factors are necessary because radio physics doesn't always return hard, clean numbers for signal bandwidth—and even when it does, strict adherence to those numbers doesn't always ensure safe, practical and efficient radio communication at a price and complexity affordable by real people. That's why FCC's Amateur Radio rules—and therefore, this article—only go so far in defining signal bandwidth and purity: Safe, practical and efficient radio communication at a price and complexity affordable by real people is what Amateur Radio is all about.—*WJ1Z*

Finding Your Radio's Frequency-Display Accuracy

Finding out where you're really operating requires that you know your radio's frequency-display accuracy. Your transceiver's operating manual may specify it. If you can't locate this information (or if your radio's age makes you wonder if its published display-accuracy specification still holds), you can estimate the accuracy yourself.

Published accuracy specs usually speak in *relative* or *absolute* terms. *Relative accuracy* means that the display's accuracy relates to something else (you're usually told what); *absolute accuracy* means that the display's accuracy is specified directly in frequency units.

Phrases like "±10 ppm" specify relative accuracy. Translated, this particular specification means "plus or minus 10 parts per million." The "plus or minus" means that the display may read a bit high or a bit low, or anywhere in between. One megahertz is a million hertz, so "10 parts per million" means "10 hertz per megahertz." You can find how many hertz this is at your operating frequency by multiplying 10 hertz by the number of megahertz displayed. At 28.623 megahertz, then, this display's accuracy is ±286 hertz (10 × 28.623). At 1.803 kilohertz, this same display is accurate to within ±18 hertz (1803 kilohertz = 1.803 megahertz; 10 × 1.803 = 18). (Some manufacturers use scientific notation when specifying accuracy; "10 ppm," for instance, becomes "10×10^{-6}" or "1×10^{-5} in scientific notation.)

Specifying a radio's display accuracy in absolute frequency units is a bit simpler: "±200 hertz." This means that no matter where you tune in that radio's range, its frequency display will display a frequency within +200 and −200 hertz of your true carrier frequency.

You can find or confirm your display's accuracy yourself by selecting the AM mode and tuning in the highest standard-frequency-and-time signal you can receive. (That means WWV or WWVH at exactly 20, 15 or 10 megahertz; CHU at exactly 14670, 7335 or 3330 kilohertz—the higher the better.) Note the pitch of the test tones (WWV/WWVH) or time beeps (CHU). Switch to USB and carefully tune the radio until the tones you hear in USB match those you hear in AM as closely as possible. (I recommend switching back and forth between AM and USB a few times to match the tones closely.) If your rig can't receive AM, use WWV or WWVH, *not* CHU (CHU does not transmit a lower sideband), and tune your radio so that the test-tone pitches match as closely as possible when you flip between USB and LSB. *The difference in hertz between the station's exact frequency and the frequency displayed on your radio is your radio's display error at that frequency.* Even though the number you get is absolute (in frequency units), you're safer if you treat your results as conveying *relative* accuracy. In other words, if you measure an error of 150 hertz at 10 megahertz, assume that the display will be off by 450 hertz at 30 megahertz (3 × 10), and use this number when calculating how close to band edges you can go.

Even if you own a brand-new radio with well-specified frequency display error, I recommend that you use this "find it yourself" procedure at least every month or so to keep tabs on the radio's display accuracy. Record the results in your radio's operating manual for future reference.

Finding your true operating frequency. Okay, but where are you *really* operating? Once you've determined your radio's display accuracy in absolute (frequency) terms, you need to apply the ± concept and do a bit of arithmetic. Saying that your radio's display is accurate to within ±286 hertz at 28.623 megahertz means that your operating frequency is somewhere between 28.623 megahertz − 286 hertz and 28.623 megahertz + 286 hertz—in other words, somewhere between 28.62271 and 28.62328 megahertz. In a radio specified to display frequencies to within ±200 hertz, your carrier frequency is actually somewhere between 10143.55 and 10143.95 kilohertz when the displayed frequency is 10143.75 kilohertz.—*WJ1Z*

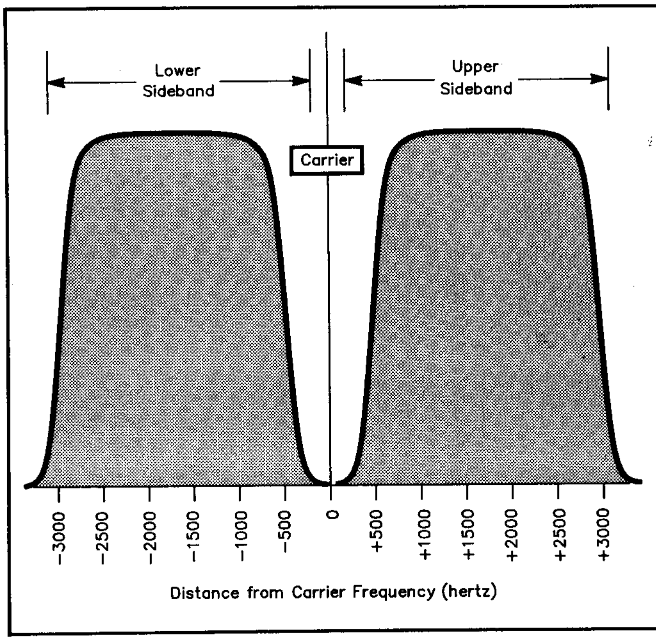

Fig 3—Modulating a carrier for AM (amplitude modulation) generates upper and lower sidebands that consist of the carrier frequency ± the modulating frequencies. Overmodulating a carrier or overdriving an amplifier with an AM signal generates wider-than-necessary sidebands called *splatter*. Both AM sidebands must stay on frequencies your license allows you to use.

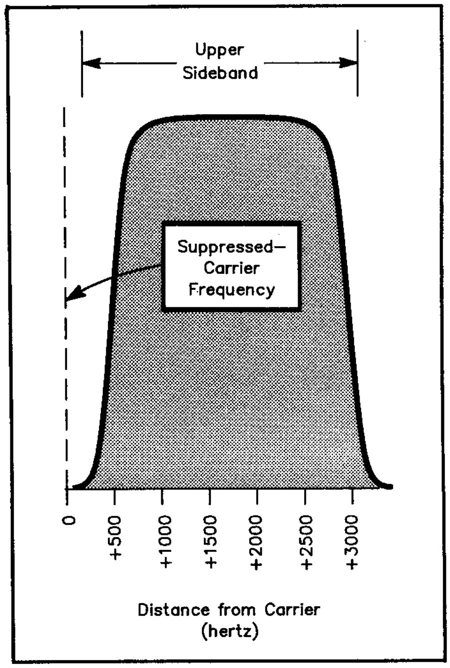

Fig 4—A *single-sideband* (SSB) signal is a full-carrier, double-sideband AM signal with its carrier and one sideband suppressed. This drawing illustrates a USB signal. Modified to show an LSB signal, this drawing would show the suppressed carrier on the right and a frequency scale labeled 0 to −3000. Hams traditionally use LSB below 10 megahertz and USB above.

edge. Your frequency display shows your *suppressed-carrier* frequency. If you're operating LSB *below* a band edge or USB *above* a band edge, position your suppressed carrier as you would your transceiver's CW signal. (I recommend doing this because your radio's carrier suppression is not perfect, and because your radio may emit a carrier—in effect, a CW signal—in a **TUNE** mode even though you've otherwise set it for SSB emission.) Tune your transceiver no closer to the band edge than its maximum display error + half of your radio's CW bandwidth + the next display increment farther from the edge. See "CW" for details.

If you're operating LSB *above* a band edge or USB *below* a band edge, space your suppressed carrier from the band edge by the highest audio signal your transmitter can handle + your transceiver's maximum display error + the next display increment farther from the edge. *Example:* with a transceiver that handles audio from 300 to 3000 hertz and displays frequencies with a maximum error of 300 hertz, go no closer than 3400 hertz (0.1-kilohertz display resolution) or 3310 hertz (0.01-kHz display resolution.

If All Else Fails, Think *Transmit*

Current radios and pre-microprocessor-control digital-display radios may differ in how they display receive frequencies, especially CW receive frequencies. Current rigs tend to display *the actual transmit frequency* even during CW receive; some older transceivers display their actual CW transmit frequencies only when they're switched into transmit. Trying to put an old rig and a new rig on the same frequency can be tough if you forget this.

If you're in doubt about where you're transmitting, *switch your rig into transmit without actually transmitting anything*. Look at its digital display. *That's* where you're transmitting. The relationship between what it displays in receive mode and what it displays in transmit may be affected by split, RIT, XIT or CW-offset adjustments; what it displays in transmit is the real thing.—*WJ1Z*

Modes Generated By Feeding Non-Voice Audio into an SSB Transmitter

Many hams operate RTTY, AMTOR, fax, slow-scan TV and 300-baud HF packet by feeding these modes' baseband audio into their SSB transmitters. As with SSB voice, your transceiver's frequency display indicates your suppressed-carrier frequency when you operate in this way.

Because these modes' baseband audio is frequency-modulated (FMed), the resulting RF emissions have *multiple* upper and lower sidebands. You might think, for instance, that the frequency-shift keying (FSK) used by AMTOR, 300-baud packet and RTTY creates a signal that looks like two CW signals side by side. Not so! Fig 5 shows a generic example of practical direct FSK.

Never Transmit *On* the Edge

Because your signal has width, and because band and subband frequency limits are limits to stay *inside of*, never operate *at* a band-edge frequency—even if you operate an SSB, suppressed-carrier mode that *should* fall safely in the band. How do you know that your transmitter isn't going to leak enough carrier to get you in trouble? You *don't*—so never operate at the edge.—*WJ1Z*

I don't recommend that you try to operate as close as possible to a band edge with such emissions unless you know enough about them to calculate your bandwidth. (If you know that, you don't need this article!) Instead, I recommend that you keep your signal away from band edges by positioning your suppressed carrier as you would for SSB voice operation. Because the maximum tone frequencies used by these image and digital modes are all lower than the highest frequency used in voice transmission *and* because your radio includes filtering that limits the bandwidth of the signal you transmit, you should stay safely within the band. Comparing frequencies with other keyboard/image-mode operators is a more important practical problem. The sidebar, "Where the Heck Am I?," sheds light on this issue.

*Moving to a desired RTTY or AMTOR operating (*mark*) frequency* is easy once you know how to do the arithmetic. For example, say you want to operate AMTOR at 18.105 megahertz, and you're going to get there by feeding audio from your multimode communications processor into your SSB transceiver. Your know that your AMTOR signal consists of two signals, *mark* and *space*, 170 hertz (0.00017 megahertz) apart, and that, by convention, *mark* should be the higher of the two. So you know that "operating AMTOR at 18.105 megahertz" actually means "operating AMTOR with my *mark* at 18.105 megahertz and my *space* at 18.10483 megahertz" (18.105 − 0.00017).

Where the Heck Am I?

Our radios' frequency displays complicate communication via image and keyboard modes that involve feeding audio into an SSB transmitter. First, there's the matter of tone *sense*—that is, which tone (*mark* or *space*, or *white* or *black*) is higher in frequency than the other. At MF/HF, *mark* (*white* in image systems) is conventionally the higher. Because the audio-frequency-shift-keying (AFSK) modems many hams use implement mark as *lower* than space, hams conventionally feed their AFSK modems into SSB transmitters set for LSB. This inverts the tones, *mark* comes out on top, and everybody's happy. Well, almost.

There's still the problem of telling the other operator what frequency you're on. Do you just read your frequency display? (Remember, all it shows is your suppressed carrier frequency.) Do you calculate your *actual* RF tone frequencies by adding them to (or subtracting them from) your carrier frequency? Do you average the two frequencies and communicate the imaginary center frequency between them? (This is common in some areas of the telecommunications industry.)

Arguably, calculating your actual RF tone frequencies is best, and most MF/HF RTTY/AMTOR operators consider *mark* to be the operating frequency. Fax and SSTV? Treat them like SSB: Operate on the basis of your suppressed-carrier frequency.—*WJ1Z*

Further Reading

On necessary bandwidth, modulation and demodulation: Larry D. Wolfgang and Charles L. Hutchinson, editors, *The ARRL Handbook for Radio Amateurs*, 1991 edition (Newington: ARRL, 1990), Chapter 9.

Richard Palm, editor, *The FCC Rule Book*, 8th edition (Newington: ARRL, 1991), Chapter 9.

On Band Plans: Robert J. Halprin, editor, *The ARRL Operating Manual* (Newington: ARRL, 1987), Chapter 2.

Jay Mabey, editor, *The ARRL Repeater Directory*, 1991-1992 edition (Newington: ARRL, 1991).—*WJ1Z*

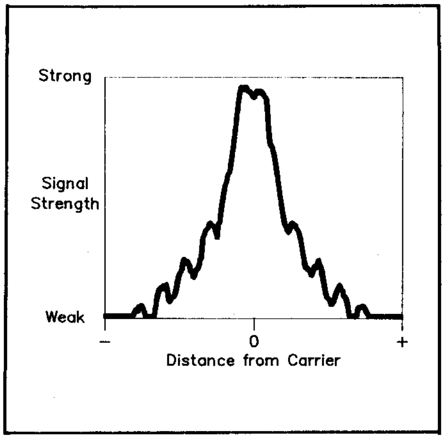

Fig 5—Feeding an audio-frequency-shift-keyed (AFSK) data signal into an SSB transmitter results in FSK on-air. Because the actual spectrum generated may vary from modem to modem even for the same operating mode, and because FM (of which FSK is one case) generates *multiple* upper and lower sidebands as shown here, I recommend treating AFSK-via-an-SSB-transmitter modes like SSB when setting your operating frequency—unless you know enough to calculate or measure your signal bandwidth directly.

Your multimode communications processor manual says that the processor transmits and receives its AMTOR *mark* at 2125 hertz and *space* at 2295 hertz—reversed in frequency sense to the way you need them. No problem! Just *operate your radio in the LSB mode* to reverse the tones.

Okay, but just switching your rig to LSB and feeding this audio into the radio puts you on the wrong operating frequency if you tune your transceiver to display **18.105**. This is so because your radio's frequency display indicates your suppressed-carrier, not your *mark*, frequency. Figure out what your display *should* read by adding your *mark* frequency (2195 hertz [0.002195 megahertz] in this example) to the *operating* frequency you want. Okay: 0.002195 + 18.105 = 18.107195 megahertz—18107.195 kilohertz. (Your radio probably only tunes in 10-hertz steps, so you'll have to set it to either 18.10719 or 18.10720 megahertz; the error doesn't matter. Your display probably shows these frequencies as **18.107.19** or **18.107.20**.) So, to recap: To operate 170-hertz-FSK AMTOR at 18.105 megahertz using 2195-hertz *mark* and 2295-hertz *space* tones, set your radio to LSB and tune it to display 18.107.19 or 18.107.20 megahertz.

FM Voice and Data

FM generates *multiple* upper and lower sidebands in an array that depends on the modulating frequency and how far the carrier swings—*deviates*—from its nominal (carrier) value. (Your FM radio's frequency display shows your carrier frequency.) This relationship is hard to show graphically, so I won't even try. Instead, I'll cut to the practical: If you operate a properly adjusted commercial FM radio according to its manufacturer's instructions *and according to the ARRL Band Plan appropriate for your band of choice*, you should stay safely away from band edges.

Putting It All Together

Now that you know that our official band limits—round, easy-to-remember phrases like "7.0 to 7.3 megahertz"—are actually narrower *in practice* because of our signals' width, here's how to put that knowledge to use. Calculate your radio's *practical* band limits for each of your operating modes and subband segments, and record this information in a Personal Band Limits chart. (For instance, if you find that you can safely operate 40-meter LSB only at carrier frequencies between 7153.1 and 7299.5 kilohertz, record these frequencies as your *real* band limits for 40 phone, not 7150 and 7300.) Keep it right beside your radio, and *use it* when you operate.

What Your Frequency Display Doesn't Tell You—Reprise

Your frequency display doesn't tell you your signal's width relative to the displayed frequency—undisplayed information that's pretty darned important. You need to know something of your signal's width when choosing an operating frequency so you won't bump into other signals or slip out of the band. Signal width is only part of the story, though. You should also be aware that your frequency also *doesn't indicate whether:*

- your license allows you to operate at your chosen frequency
- the mode you've selected is allowed at that frequency
- your operating power is appropriate or legal at that frequency
- another station is already operating at that frequency
- an ARRL Band Plan exists for that frequency, and you're operating in accordance with that band plan
- that frequency is shared with other radio services on a noninterference basis
- an FCC-declared communications emergency exists that takes priority over normal Amateur Radio communication at that frequency

Frequency consciousness may seem complex and scary. It may seem like you have to know almost everything about everything before you do so much as call a CQ. But you don't. Many parts of the frequency-consciousness picture—stuff like your operating privileges, power and whether or not your operating frequency is shared—don't change very often. So you review them in your mind, check your Personal Band Limits, and go on the air. Once you're on the air, you can rightfully devote most of your frequency attention to your transceiver's two largest features—its tuning knob and its frequency display.

Feedback

☐ Bud Thompson, NØIA, points out an error in David Newkirk, "What Your Frequency Display Really Tells You," *QST*, Aug 1991, pp 28-32. The sample calculation in paragraph 2, column 1, page 32, mistakenly uses an audio *MARK* frequency of 2195 rather than 2125 Hz. Beginning with sentence 3 of that paragraph, the example should read:

> Figure out what your display *should* read by adding your *MARK* audio frequency (2125 hertz [0.002125 megahertz] in this example) to the operating frequency you want. Okay: 0.002125 + 18.105 = 18.107125 megahertz or 18107.125 kilohertz. (Your radio probably only tunes in 10-hertz steps, so you'll have to set it to either 18.10712 or 18.10713 megahertz; the ±5-Hz error doesn't matter.) Your display probably shows these frequencies as **18.107.12** or **18.107.13**. So, to recap: To operate 170-hertz AFSK AMTOR at 18.105 megahertz using 2125-hertz *MARK* and 2295-hertz *SPACE* tones, set your radio to LSB and tune it to display **18.107.12** or **18.107.13** megahertz.

More on finding your frequency in keyboard modes appears in this month's Hints and Kinks, beginning on the previous page. —*WJ1Z*