Carrier Sleuthing, part#1

Introduction

Be sure to read the other parts of this series. Part#1, Part#2, Part#3

There is a world out there that many radio hobbyists don't even realize exists. It is the world, or sub-hobby, of Carrier Sleuthing. Carrier Sleuthing is the art of detecting and visualizing radio carriers and their associated modulated sidebands and artifacts on a high-resolution waterfall display. A variety of free spectrum analyzer software is available and will produce the results we want and allow us entry into this world.

It sounds complicated and unattainable by the casual hobbyist. It really isn't. If you have a quality radio capable of single sideband reception and a computer you're basically ready to go. That radio can be a physical radio or a Software Defined Radio (SDR). Only a minimal antenna is required. If you've been in the radio hobby for a while, you already know much of the terminology and theory. You can carrier sleuth in any part of the radio spectrum: VLF, mediumwave (MW), shortwave (SW), VHF, and on up. You will see and log *fantastically weak signals*, many of which are right at the noise level, many of which you won't even hear a trace of audio from your radio's speaker or headphones. It sounds fantastic, doesn't it. A new DX world awaits you. If you are bored with radio, tired of 10, 20, 30, or 50 years of traditional DXing, depressed because "there isn't anything on shortwave anymore", "I can't DX like the big guns on the coast", "I can't put up a big antenna", "I'm too old to get back into antenna work", then read on.

I've carrier-sleuthed on many receivers. The better ones, like the SDRs or the tabletop models, are usually more frequency stable and the carriers on the display won't "wander" much in frequency due to receiver oscillator drift. The trick is to turn your receiver on and leave it on. Mine runs for days sometimes. Some of the receivers I've used

are the ICOM IC-718, Kenwood R-2000, even a portable Tecsun PL-880. SDRs I've used: the SDRPlay RSP1A & 1B, SDRPlay RSPdx, and the Airspy HF+ Discovery.

So How Do I See Radio Signals?

Free spectrum analyzer software (most of it runs on Windows) decodes the audio output of your radio and presents it in a moving graphical display called a waterfall, like a strip chart. If you're using a real radio, the audio output of your receiver connects to the line-in or microphone input of your computer through a shielded audio cable. The software then analyzes and displays the spectrum of the audio signal. If you're using an SDR receiver and running SDRConnect, SDRuno, SDR#, HDSDR, SDR-Console, or any other SDR receiver software, its audio output can be virtually connected to the spectrum analyzer's input through a virtual audio cable. It's also possible to physically connect the audio from the computer's headphone or speaker jack back into the microphone jack, like we would do using a real radio.

What Produces the Carrier I'm Seeing?

The receiver must be able to decode single sideband, or SSB, either upper sideband (USB) or lower sideband (LSB). Seasoned radio hobbyists know that when you tune a radio slightly above or below a station's carrier frequency using single sideband, a beat tone is produced. If we use upper sideband (USB) and tune 1 kHz below, we hear a 1 kHz tone in the headphones. Conversely, if we use lower sideband (LSB) and tune 1 kHz above the station's frequency, we also hear a 1 kHz tone in the headphones. Using the spectrum analyzer software connected to the radio's audio output, we might look at the audio spectrum from 0 - 2000 Hz. Converted to a time versus frequency strip chart, or so-called waterfall, we will see a running line at the midway point, or 1000 Hz. That is the carrier. We also see everything else in that 2 kHz passband. Other carriers, weak as they might be and down to the receiver's Minimum

Discernible Signal (MDS) threshold, are likely to be there too. Most software allows either a traditional vertical waterfall or a horizontally moving strip.

How Weak?

What you might not realize is there are a huge range of signals "viewable" which are below the audio level of what you can hear in your speaker or headphones.

I'll illustrate. Let's have a look at an S-unit/signal-voltage/signal-power chart I produced a few years ago:

S-unit	μV	dBμV	dBm
S9	50.0	34	-73
S8	25.0	28	-79
S7	12.5	22	-85
S6	6.3	16	-91
S5	3.2	10	-97
S4	1.6	4	-103
S3+1.9dB	1.0	0	-107
S3	0.8	-2	-109
S2	0.4	-8	-115
S1	0.2	-14	-121
S0	0.1	-20	-127
S0-5dB	0.05623	-25	-132
S0-10dB	0.03162	-30	-137

S = strength unit (like the old days!)

μV = microvolts of signal received by the antenna

dBμV = microvolts, in decibels above or below one microvolt (a logarithmic scale)

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dBm = power, in decibels above or below one
milliwatt field intensity at the antenna (a
logarithmic scale)
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The dBμ column (actually more correctly dBμV) is what your modern SDR chip-based portable radio reports in its display. In the SSB mode, most quality receivers can detect and demodulate an AM (amplitude modulated) signal down to about S-3 or so. That is about 1 microvolt, or -107 dBm. From this the receiver will produce a faint but intelligible, copyable audio signal. A little below this level you'll know there is a signal there, but it's not intelligible. Of course intelligible reception also depends on your antenna, atmospheric noise, and how quiet your radio location is. Weaker than that 1 microvolt level there are signals underneath which you wouldn't even notice when you spin the dial past them. A good SDR receiver or quality tabletop receiver will have a Minimum Discernible Signal level lower than -130 dBm, or 6/100ths of a microvolt! (0.06 μV). Signals at those levels are undetectable in your headphones but are plainly viewable by spectrum analyzer software.

A Word on Antennas

It might surprise you that you can carrier sleuth effectively on almost any antenna. This past week I've been sleuthing on a home made one meter diameter single turn loop hung in a window and connected to my ICOM IC-718 ham transceiver with 20 ft. of RG58 coax. All of the screenshots shown in this post were received on this antenna and radio. So, take note that an outside antenna is not necessarily required.

The best antenna setup will be a low noise one, and may be essential if you are in a high electrical noise environment. Luckily, low noise antennas can be very simple to erect. The Loop-on-Ground (LoG) and the Dipole-on-Ground (DoG) are two very simple

antennas that are easy to get together and work well for carrier sleuthing. See my article on the Loop-on-Ground antenna.

Mediumwave Carrier Sleuthing

Mediumwave carrier sleuthing opens up a new world on mediumwave. Tune to an active channel and you might see 5, 10, 15, or more carriers on the spectrum analyzer's waterfall once refined and zeroed-in. Each might be separated by only a fraction of a cycle (Hz) or a number of cycles. Though stations are assigned to a channel, they almost always deviate from their assigned frequency by a few cycles up to perhaps 30 cycles. Their actual offset thus becomes sort of a "fingerprint". The strong carrier is probably your local station, but who and where-located are the others? This is where the fun begins. The people at MWLIST produce a huge channel offset list for MW stations across the world. Looking at the carriers on your waterfall, you can compare their offsets to this list and over timely observations determine which stations to log.

MWLIST Channel Offset List

On mediumwave, North and South America follow 10 kHz channel spacing. For the rest of the world, it's 9 kHz. Are you in North America and want to DX the world on MW using your simple loop antenna in a window? Or maybe you have an ultra quiet loop-on-ground (LoG) or dipole-on-ground (DoG) antenna out in the yard? You can. Set your receiver on a likely 9 kHz channel and watch at select times every day throughout the year. I guarantee you will soon see activity. Pay careful attention to sunrise/sunset times throughout the world. Download the wonderful, free Simon's World Map from the creator of SDR-Console. Consult the MWLIST station list and offset tables. Make an educated guess at what stations you have seen and enter them in your log. Are you on the east coast of the U.S. and want to log KOA-850, Denver? There's one you might only actually "hear" a few times a year. But if you carrier sleuth it'll be visible every night. You just need to know its offset to 850 kHz

and look for it in your waterfall display. Watch every night, watch through solar storms and auroral disturbances, and see the vagarities of ionospheric changes. You will find it fascinating.

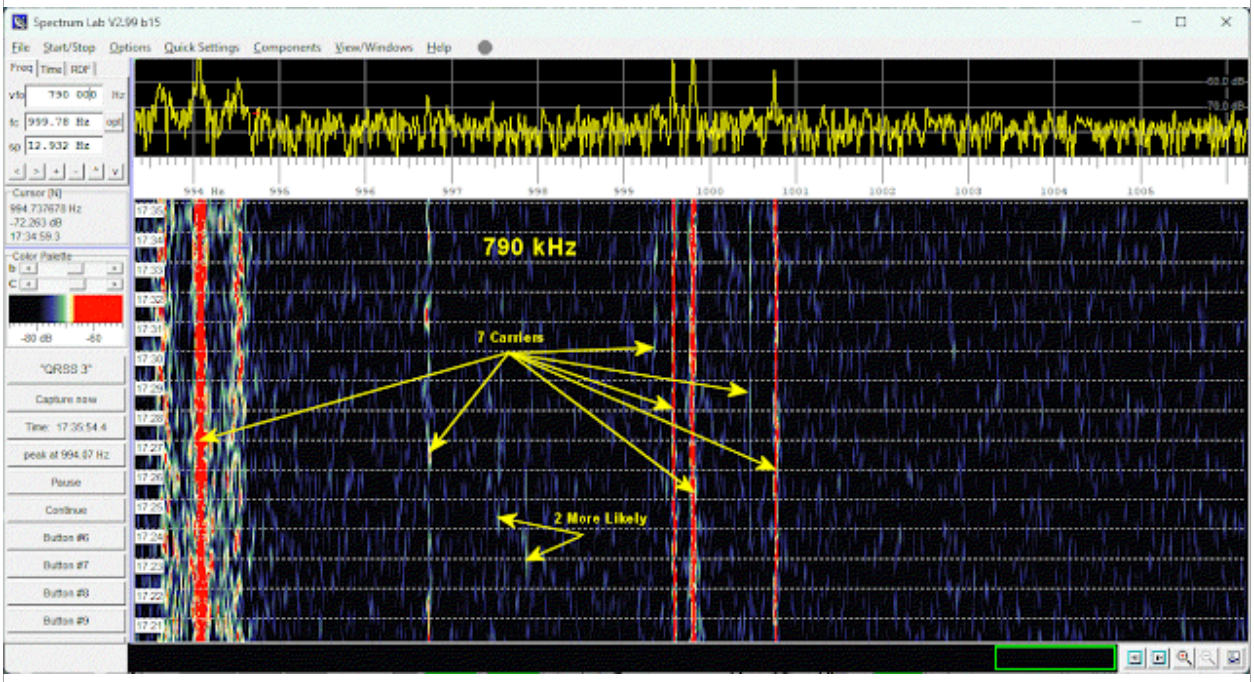
MWLIST Asia

MWLIST Europe, Africa, and Middle East

MWLIST North America, Central America, Caribbean

MWLIST South America

Click any image for the bigger picture.

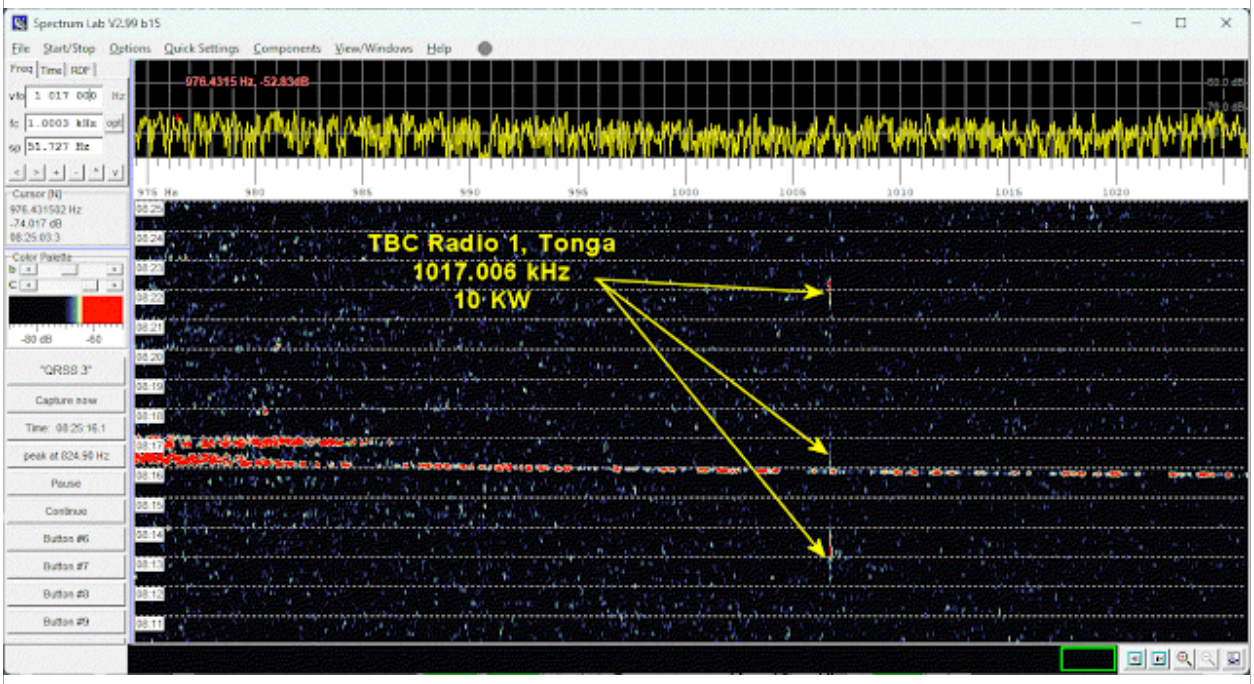


790 kHz, daytime, Rochester, NY

Shown above is an example of MW channel 790 kHz as received in the Rochester, New York area near mid-day. The spectrum analyzer software is Spectrum Lab, free. We are receiving using USB at an offset of -1000 Hz (1 kHz). Reception was using a simple, single turn home made loop fed through an inexpensive balun and 20 ft. of coax to an ICOM IC-718. Fully, 7 stations (and 2 more likely) are present in the waterfall. The strong one at the left of the display is the Watertown, NY station, WTNY, nearly 6 cycles low in frequency. Likely candidates for the others:

(D)WTNY-790 (1.0 KW) NY, Watertown 159 miles
(D)WLSV-790 (1.0 KW) NY, Wellsville 119 miles
(D)WAEB-790 (3.6 KW) PA, Allentown 321 miles
(D)WPIC-790 (1.3 KW) PA, Sharon 319 miles
(D)WSGW-790 (5.0 KW) MI, Saginaw 508 miles
(D)WPRV-790 (5.0 KW) RI, Providence 528 miles
(D)WAMM-790 (1.0 KW) VA, Mount Jackson 491 miles
+2 more

This is daytime reception on the AM broadcast band! During hours of darkness you may see many more carriers. In the dead of winter in the northern hemisphere (December-January), you will see many more carriers too, when the ionosphere's D-layer absorption is the lowest for the year. This is the exciting phenomena of winter daytime skywave DX.



1017 kHz. TBC Radio 1, Tonga

Now for an exciting catch this morning, shown in the image just above. Between 0811-0824 UTC, TBC Radio 1, Tonga, transmitting at 10 KW on 1017 kHz faded up a couple of times and the carrier showed up on the waterfall. Its frequency is about 6 cycles above 1017, at 1017.006, which matches perfectly with the MWLIST offset table. The MW station is at a distance of 7578 miles! Timing was approximately one hour before sunrise here in Rochester, NY. A full darkness path existed between here and Tonga. This was accomplished with a simple one turn loop hanging in a window. The spectrum analyzer software is Spectrum Lab, free.

Some Words on Logging

I log for pleasure and for myself. If I'm 90% sure of a station, I'll check some more just to be sure and then log it. Look, you're not

applying for a job here and you're not submitting your log to the National Science Foundation for scientific approval. You're recording your listening history and presumed catches so that one day you might go back and remember the fun times you had digging out the DX.

Shortwave Carrier Sleuthing

Now you're talking. Mediumwave sleuthing can be tough, but if you persist, you will soon get to know who is where on your display. Shortwave sleuthing I find actually a little easier. Stations are generally a little easier to identify. A number of SW schedules are currently produced twice a year and updated in between, too: HFCC, EiBi, Aoki, and more. Consult these. Get familiar with them. There are websites which show SW schedules, most are derived from one of these lists. Here are a few:

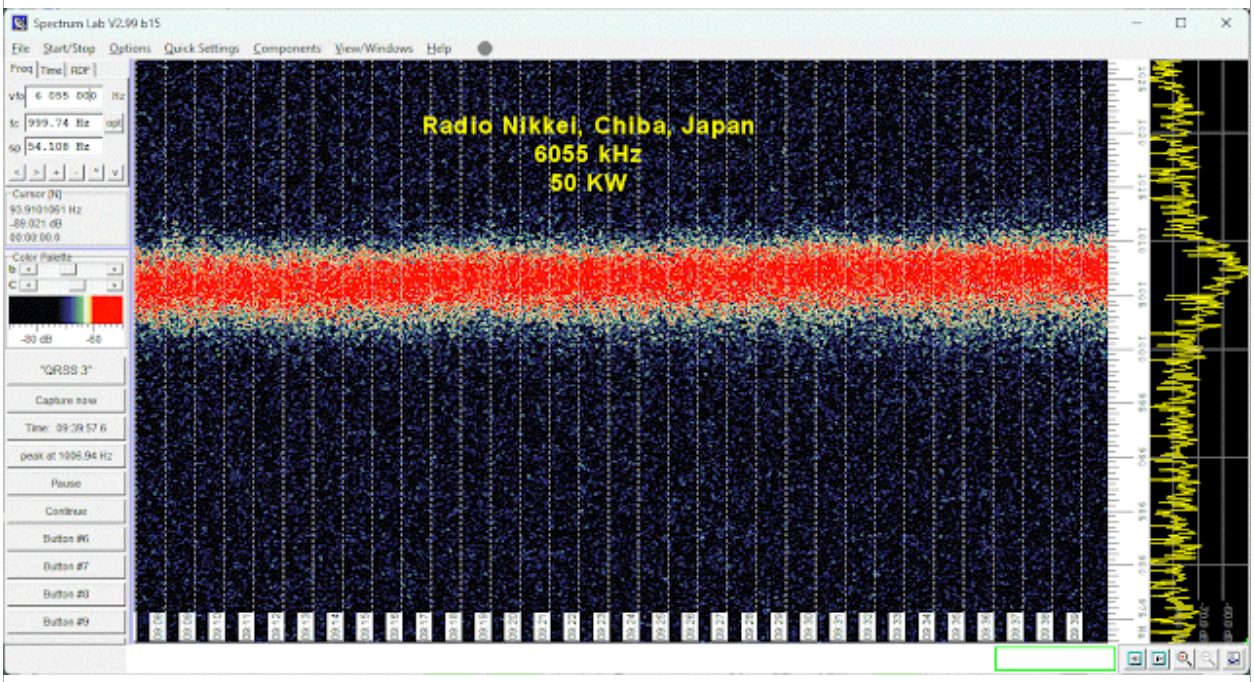
SHORT-WAVE-INFO

Shortwave.Live

Shortwave DB

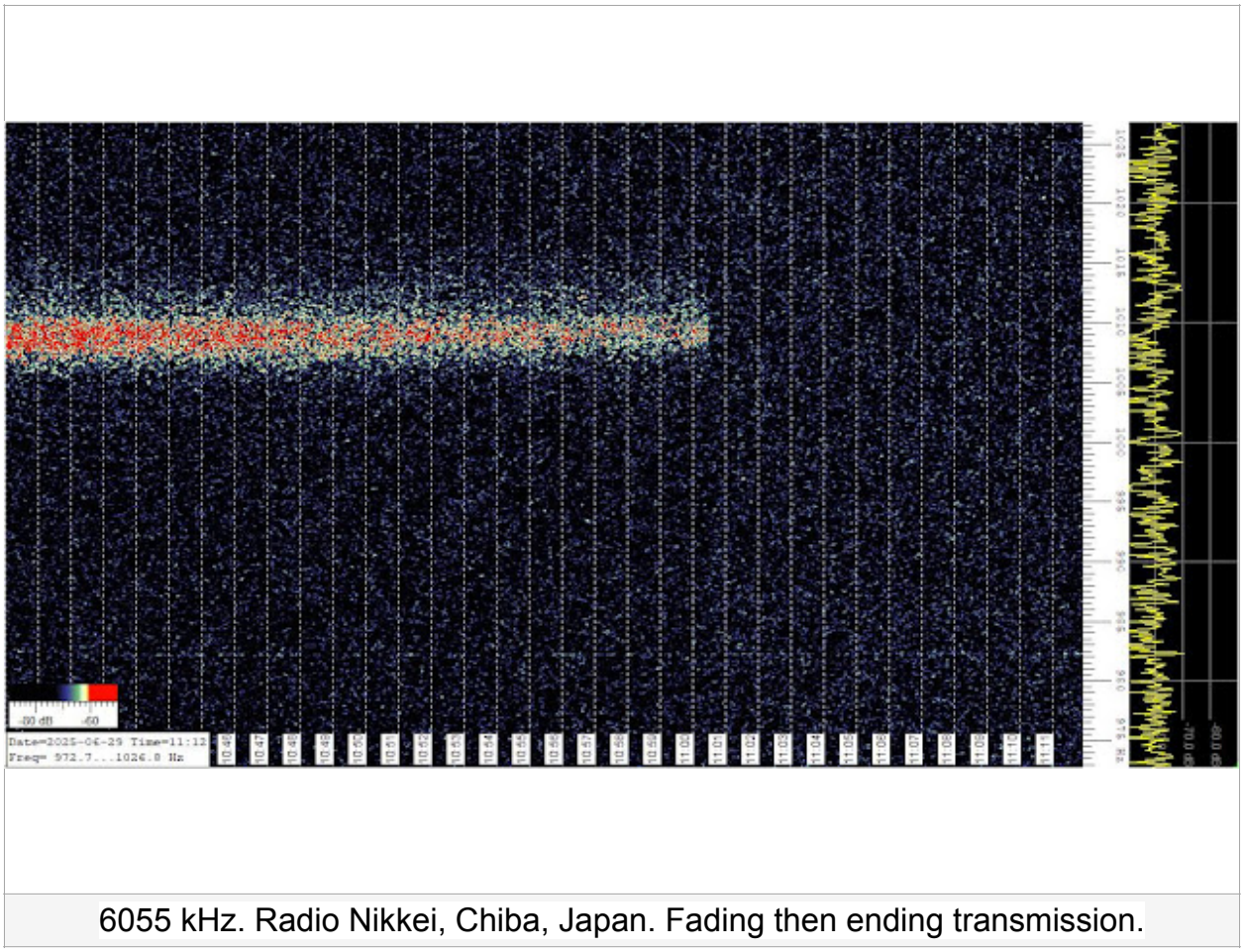
ShortwaveSchedule.com

I love to watch Asian carriers start coming in every morning as the sun rises across the western Pacific, approaching the Asian continent. Coincidentally in the summer, sunrise is also rapidly approaching here on the northeast east coast of the U.S. Many Asian stations in the 49 meter and 41 meter bands will be gaining strength. The 31 and 25 meter bands are coming alive too as the sun rises higher throughout the morning. Radio Nikkei 6055 kHz, Chiba, Japan, with a power of 50 KW is a favorite to watch. It is easily detectable on a simple loop antenna like (or similar to) a YouLoop. R. Nikkei produces a strong carrier display on the waterfall, though their carrier tone is only barely detectable in headphones. No voice audio is apparent when tuned exact.



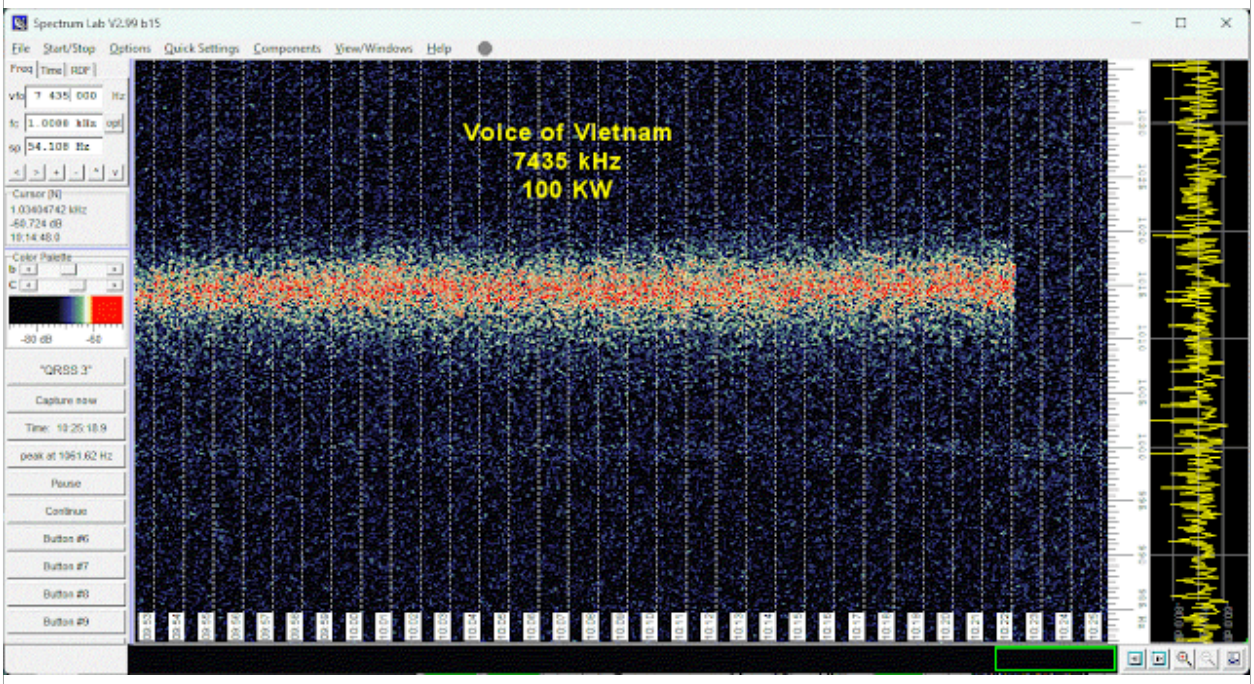
6055 kHz. Radio Nikkei, Chiba, Japan

Shown in the first shot is Radio Nikkei, 6055 kHz, Chiba, Japan at the 0900 UTC hour. Its carrier had been increasing in strength as sunrise approached Japan. The signal path is across extreme northern Alaska and northern Canada into the Rochester, NY area. In the second shot Nikkei's signal is fading as Rochester is in full daylight by 1100 UTC and suddenly Nikkei ceases its transmission at 1101 UTC.



6055 kHz. Radio Nikkei, Chiba, Japan. Fading then ending transmission.

More interesting perhaps is 7435 kHz. Listed for this frequency at this hour (1000 UTC) is the Voice of Vietnam, at 100 KW and is shown by its schedule to end its transmission at 1030 UTC. I am 90% certain this is indeed the Voice of Vietnam, but I'm uncertain of its signal path. Long path seems certainly possible, as that path is in near total darkness. At this time the short path is in total sunlight, although not far from the sunrise/sunset terminator. The carrier peaks precisely at the 1100 UTC hour timeframe when the maximum amount of darkness exists on the long path. More study is needed.



7435 kHz. Voice of Vietnam, Son-Tay, Vietnam. Ending transmission at 1023 UTC.

Wrap Up

I would encourage you to try Carrier Sleuthing. There is no financial outlay beyond the radio and computer you already have. There is a small learning curve at the beginning to learn how to use the spectrum analyzer software.

In the next part we will examine the Carrier Sleuthing listening post.