Cellular Surplus

Surplus cellphones aren't easily converted to ham use, but equipment from cellular relay sites can be a gold mine for hams. And tons of it is showing up on the surplus market.

This month, I'm going to talk some more about using some of the tons and tons of 900-MHz surplus hitting the market (see July's "Final Frontier" column for the initial discussion). We'll look at a variety of filters, antenna systems, and power supplies, and at how hams can retune them for use on the amateur bands. Plus, we'll take a look at something called "dB return loss" and activity news from the microwave bands.

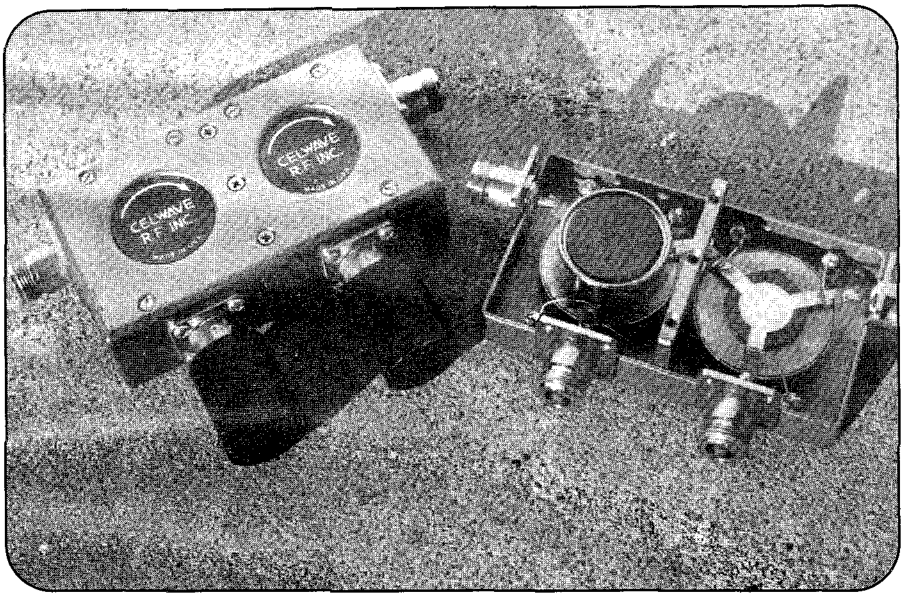

Photo A. Typical cell site circulators. These special filters are used to prevent interference when multiple transmitters and receivers operate in close proximity to each other. See "Microwave Mini-Glossary" for a more detailed explanation.

Filters

With all the thousands and thousands of cellphone sites out there, any good location for your 902- to 928-MHz ATV system, repeater, or SSB station is probably going to be near a cell site. If you don't block out all those strong 880-MHz transmitters, you're not going to hear any weak 900-MHz signals. What you'll need is a bandpass filter to allow only 900- to 910-MHz signals to pass through into your receiver. Many surplus cell site filters will do the job nicely.

In general, bandpass filters tune down farther in frequency than they tune up, and there is quite a variety of filters that can be retuned into our 902- to 928-MHz ham band. Part of this is engineering. If I want a low-loss 900-MHz interdigital filter (see Microwave Mini-Glossary), then I would design it for 905 or 910 MHz. The guys stamping them out wouldn't make all the filters exactly alike, but they'd be close enough; and with a tiny bit of capacitance, the filter could be tuned down to 900 MHz. If I designed it for 950 MHz and pulled the filter down to 900 MHz, the filter would have more loss. So the designer naturally wants to cut it pretty thin.

All the cell site bandpass filters I've worked with retuned to the low edge of our 902- to 928-MHz ham band; about half would retune to 915 MHz, a favorite spot for ATV (amateur television). Cell site filters are a good find.

PCS Band Stuff

I've built up quite a collection of filters for the 1800-MHz PCS band (Personal Communication System, the digital cellphone networks at 1.8 GHz, identifiable by ads telling you they're not cellular). But I've never gotten one to tune up to 2304 MHz or down to 1296 MHz, even with some pretty radical surgery! So the best I can say for the 1800-MHz PCS filters is to salvage them for the hardware and coax connectors.

While on the subject of 1800-MHz PCS systems, I've also collected several different PCS power amplifiers and preamps. Again, I've never worked out a modification to move the amps either up to 2304 MHz or down to 1296 MHz. The power transistors use a variety of internal matching techniques with the bond wires to optimize them for 1800 MHz. The transistors work great on 1800 MHz, but quit above 2000 MHz or below 1500 MHz. Mats Bengtsson, SM6IKY/W5, has had some success using 1800-MHz PCS transistors on 1296 MHz with some careful-

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Microwave Mini-Glossary

For those of you who (*like your editor*) aren't familiar with some of the terms used in this article, here's a brief "mini-glossary" to help you understand better...

Bond wires—Small wires thinner than a human hair used to make connections inside transistor and IC (integrated circuit) packages.

Circulator—A three-port ferro-magnetic device that only allows radio waves to travel between certain ports (see also *Isolator*). Isolators and circulators will be the primary topic of an upcoming "Final Frontier" column.

Interdigital filter—A filter containing a series of $^1/_4$-wavelength elements designed to pass a range of frequencies. Due to the size of the elements, interdigital filters are rarely used below 500 MHz.

Intermodulation (intermod)—When two or more signals combine to interfere in a receiver. As an example, TV channel 2 and TV Channel 11 are 144 MHz apart. These strong signals mix in my 2-meter moonbounce receiver and create an intermod signal at 144.000 MHz.

Isolator—A two-port ferro-magnetic device that allows radio waves to travel though in only one direction. Much like a "check valve" in hydraulics.

Patch antenna—A small, usually square, patch of printed circuit board mounted above a ground plane. Patch antennas will be the primary topic of an upcoming "Antennas, etc." column.

TWT (traveling wave tube)—A special vacuum tube used to amplify microwave signals. TWTs usually have very high gain (40 dB or more), taking small microwave transmitters to the 10-watt or even 100-watt level. When combined into a complete system of power supplies, switching, and so forth, they are known as TWTAs, or traveling wave tube amplifiers.

ly designed pc boards, but, in general, the 1800-MHz PCS power amps and receiver preamps are good only for parts.

Isolators and Circulators

Isolators and circulators are special filters designed to allow multiple transmitters and receivers to operate from the same physical location (such as a cell site) without interfering with each other (see "Microwave Mini-Glossary" and Photo A). I will be devoting a future column just to circulator tricks, but, for now, I can say I've never seen a cellphone circulator that didn't either already work on 900 MHz or easily retune to 900 MHz. For the most part, hams have stayed away from these "ferrite devices" (isolators and circulators). I guess it's because most don't understand what they do, and that's a shame because "ferrite devices" are very handy!

A ferrite isolator is the RF equivalent of a diode. RF goes in, but it doesn't come back out. Let's say you put a 146-MHz isolator on your 2-meter rig. Because RF cannot travel backwards through the isolator, the 2-meter rig sees a 1:1 SWR (standing wave ratio), even if the antenna falls off! Of course, with this hookup, received signals can't get back to the 2-meter rig, either, but we can have separate isolators looking in different directions after the antenna switch.

Isolators tuned to 900 MHz are great for high-linearity ATV transmitters or 900 MHz repeaters. When using an isolator in ATV systems, the transmitter is always looking into a constant impedance load. Plus, in repeater service, the isolator keeps nearby signals from other services from getting back into the transmitter and causing intermod.

Intermod in the transmitter? Yep! We had a good example of this in our area some years ago. The 222-MHz repeater was located a few feet from an FM broadcast station. Several watts of the broadcaster's 90-MHz signal were going back down into the final transistor of the repeater and generating all kinds of mixing products. While this problem was eventually solved with band pass and notch filters, it would have been the perfect spot for a 222-MHz circulator.

Cell Site Antennas

If you have ever taken apart an antenna from a cell site, you've no doubt been quite impressed. The typical 800- or 1800-MHz cell site antenna these days is an *Aperture Coupled Patch* antenna. A small square patch antenna is excited by one of two slots etched into a circuit board underneath the patch. This way, the patch can be used on two polarizations at the same time. Phasing lines and power splitters are typically etched into the same printed circuit board on which the patches are etched. An exquisitely engineered phased array antenna is a fascinating thing to look at, but useless on the amateur bands. On the other hand, the antenna hardware, coax cable, and other parts can all be quite useful.

Power Supplies

Every cell site needs amps and amps of 24-volt DC power. The extremely rugged power supplies that produce this are designed to function reliably for years and years. You'll be needing a 24-VDC supply anyway if you're going to be playing around with cell site equipment, and the 24 VDC usually runs 28-VDC military surplus equipment just fine. Look around, the power supplies usually have controls for voltage and current limiting.

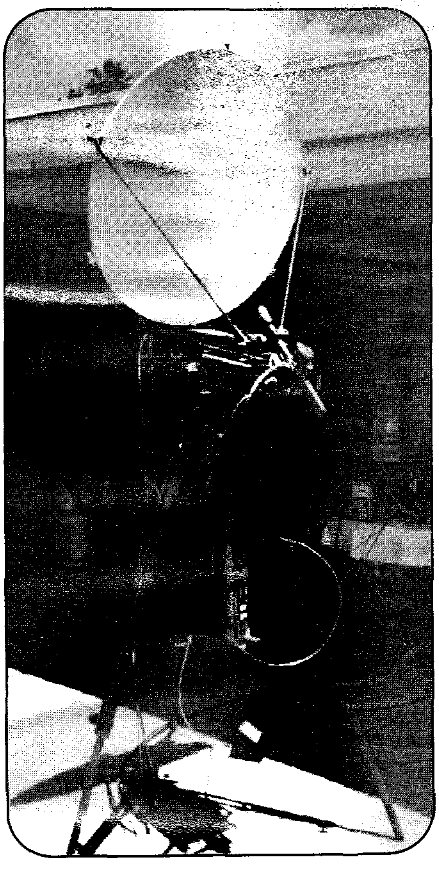

Photo B. Have tripod, will travel. Peter Bauer, W6DXJ, of El Cajon, California, is ready anytime, anyplace, to put a 10-GHz signal on the air with his tripod-mounted 30-inch offset feed dish and 15-watt TWT amplifier. (W6DXJ photo)

"German, French, Belgian, Czech, and Dutch stations were working each other on 10 GHz over a 500-mile-square area."

A few can even be cranked down to 13.8 VDC. So don't pass up those power supplies too quickly if you see some down at the surplus yard.

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Activity Reports

We have word of an excellent rain scatter event over most of northwestern Europe on June 2. German, French, Belgian, Czech, and Dutch stations were working each other on 10 GHz over a 500-mile-square area. Raindrops scatter 10-GHz signals like a snowstorm scatters a bright light that shines into it. If both stations can see the tops of the thunderstorm clouds, they can work each other on 10 GHz. Now, bouncing your signal off billions of tiny dielectric dipoles swirling around in different directions does weird things to the signal. And the human voice comes out as short broadband bursts of noise. So all of these QSOs were on CW. At least one more reason for knowing enough code to recognize your call—and the other guy's!

Events

I would like to invite everyone to Microwave Update 99. This is a world-renowned conference on microwave equipment, theory, and operating that Al Ward, W5LUA, and I will be hosting at the Harvey House Hotel in Plano, Texas, this October 21 to 23. We expect 150 or so attendees from as many as eight countries. For more information, you can contact me through *CQ VHF* or Al at <W5LUA@CSVHFS.ORG>.

Finally, Photo B shows the portable 10-GHz station of Peter Bauer, W6DXJ. A note to Pete: I see that Hughes 1177 TWT (traveling wave tube) amplifier hanging from the center of your tripod. I've personally used a Hughes 1177 on 10-GHz EME and G3WDG is currently using a 1177 on 10-GHz EME. All you need is a bigger dish!

Until next time, have fun and let's see some more action on ham radio's microwave bands! ■

"dB Return Loss" and VSWR

For about the first 50 years of radio, antenna performance was measured by walking along the open-wire feed line with a voltmeter. Sometimes the meter was slid along the line, sometimes people just made a measurement every few feet. If the highest voltage measurement was 100 volts and the lowest measurement was 50 volts, then the VSWR (voltage standing wave ratio) was 100/50 or 2 to 1 (2:1). If the reading was a nearly constant 100 volts, then the line was said to be "flat." It was certainly a useful measurement method for the equipment of the 1920s, but as coaxial cable was introduced, this measurement method lost favor. Yes, you could drill holes in the coax every few feet and measure the voltage between the center conductor and the shield, but this is hardly a popular way to test antennas.

Next came the SWR meters we typically use today. These meters measure the current in the coax cable. With "directional couplers," the current going out and the current reflected back are independently measured and the antenna SWR is calculated. But that reading of 2.5:1 or 1.2:1 really doesn't tell us much about what's going on in the antenna.

I don't know exactly when the idea of *decibel return loss*, or *dBrl*, was introduced, but it seems to have come out of the telephone company in the 1940s (*back when there was only one telephone company—ed.*). The term dBrl expresses the difference, in decibels (dB), between how much power goes out and how much power is reflected back. If half the power is reflected, then the system has a 3 dBrl (3 dB representing either a doubling or halving of power). If 1/10 of the power is reflected, then the system has a 10 dBrl (you guessed it, 10 dB loss represents 1/10 of the original power; and 10 dB gain represents 10 times more power*). If 1/100 of the power comes back, then you have a 20 dBrl.

You've probably noticed by now that the higher the dBrl number is, the lower your SWR is. This is particularly useful when the reflected powers are very, very low. If I reduce the reflected power from 40 dBrl to 50 dBrl, I've reduced reflected power by 10 dB. You'll have to sharpen your pencil several times to calculate the difference between 1.020 and 1.006 SWRs which represent the same change in reflected power. See the Table for additional examples.

Table.

Decibels Return Loss (dBrl)	Equivalent SWR
3 dBrl	5.8:1
6 dBrl	3.0:1
10 dBrl	1.9:1
20 dBrl	1.22:1
30 dBrl	1.07:1

Table. Comparison of reflected power measurements expressed in dBrl (decibels of return loss) and SWR (standing wave ratio). The smaller the return loss, and lower the SWR, the easier it is to work with dBrl, which increases as the return loss decreases. See text for additional details.

*For an excellent introduction to decibels, see "You Don't Have to be Einstein...to Understand Decibels," by Ron Hranac, NØIVN, in the December, 1997, *CQ VHF*.