Proper use of the RC-292 antenna

by David M. Fiedler

Frequency managers at all levels are not taught much in the way of frequency dependent antenna characteristics and tend to treat all antennae and all VHF-FM frequencies in the same manner.

The RC-292 ground plane FM antenna has been in the Army inventory longer than most Signal Corps general officers. After all these years of good service, you would expect that we tactical communicators would know all that there is to know about the characteristics of the RC-292; unfortunately, we don't. If asked when to use this antenna, most communicators would say when operating at ranges that are too great for vehicular mounted whip antennas, when greater efficiency is needed in order to work through jamming, or when higher antenna heights are required in order to achieve better direct wave propogation characteristics.

All of these reasons are valid under certain conditions. However, they do not tell the whole story. Figure 1 is a plot of the voltage standing wave ratio (VSWR) of the RC-292. As you can see in Table 1, the VSWR varies in each band of operation.

These measurements are operationally significant because when a transmission line is terminated by an antenna whose resistance is equal to its characteristics impedance, the transmission line carries a pure traveling wave. This wave is radiated into space at the antenna, and thus a radio signal is propagated into space. The frequency at which the antenna impedance and the line impedance are the same is called the resonance frequency of the antenna and is dependent upon the physical and electrical length of the antenna. When a transmission line is not terminated into an antenna whose physical and electrical characteristics are matched to the transmitter, the voltage to current ratio is not the same for the load (antenna) as for the line. This means that all the transmitter energy cannot be radiated as a signal. Some of the transmitter's signal is reflected back toward the transmitter in the form of a second traveling wave. Those two waves (forward and reflected) interact on the transmission line to form a standing wave. In every situation, except for a perfect impedance match, some energy is reflected at the antenna and flows back along the transmission line to the transmitter. Since this energy is not radiated in the signal, it represents a loss of useable signal power; and since both communication range and the ability to operate in a jamming environment are directly related to transmitted signal strength (radiated power), this loss of power is very significant. The standing wave ratio (SWR) (k) is the ratio of maximum and minimum values of the standing wave along a transmission line. The percentage of signal reflected (r) is the ratio of reflected

Band	30-36.5 MHZ	36.5-50 MHZ	50-76 MHZ
Lowest VSWR	1.3:1	1.3:1	1.4:1
Highest VSWR	3.1:1	4.0:1	3.4:1
Max difference	1.8	2.7	2.0

Table 1

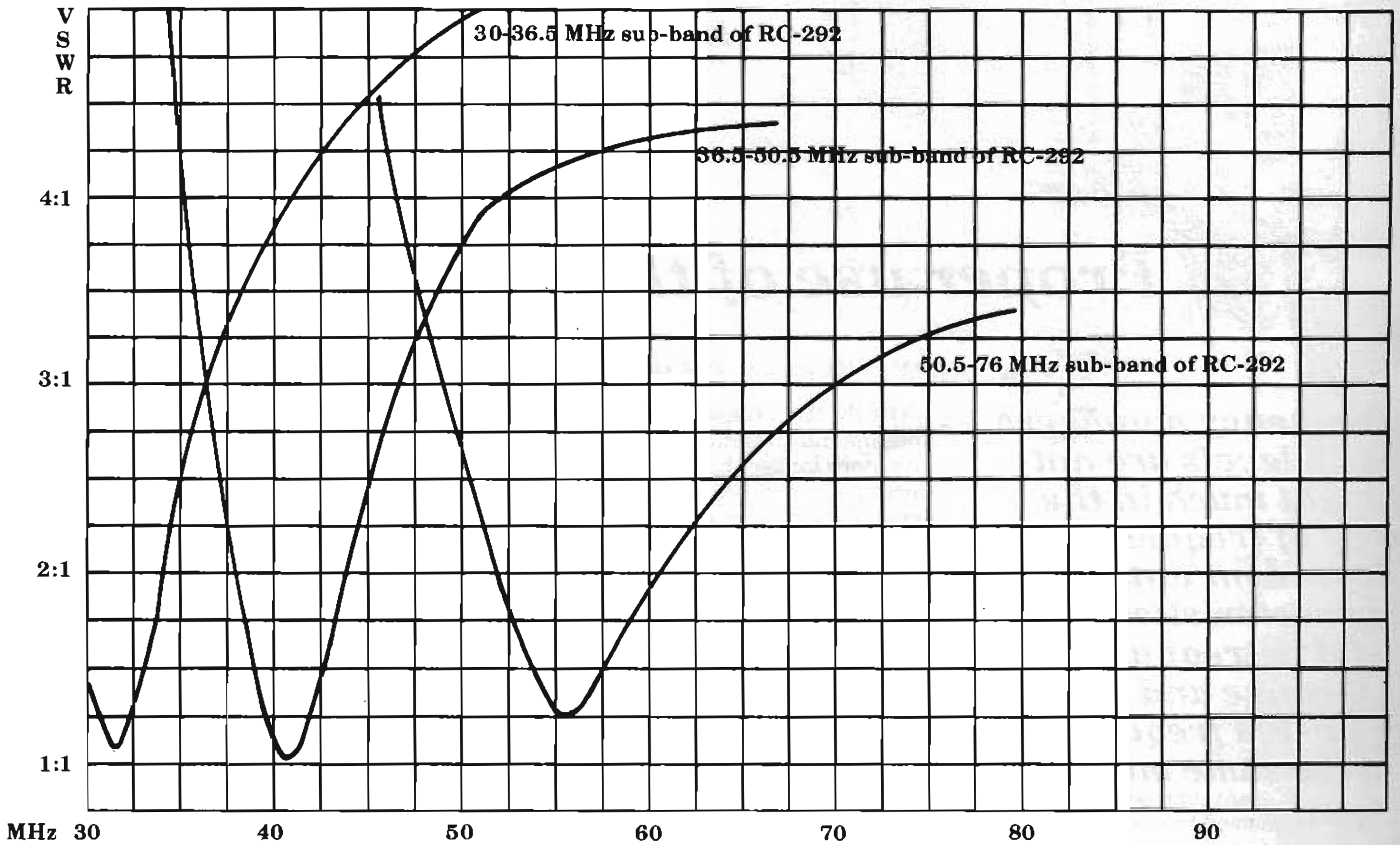

Figure 1.

current to transmitted current. The two are related by the expression:

$$k\ (SWR) = \frac{1 + r}{1 - r}$$

where r is the percentage of current reflected back to the transmitter.

The values of r lie between 0 (perfect match, no reflection) and 1 (complete mismatch, 100% power reflected). Table 2 shows the VSWR in terms of percentage of power reflected.

VSWR	Percent reflection *Reflection Coefficient*
1.0/1	0
1.5/1	20
2/1	33
3/1	50
5/1	67
9/1	80
	100

Table 2

With the above in mind, we should now examine Fig. 1, which shows the VSWR measured for the three operating bands of the RC-292 antenna. In each band, there is a point where the VSWR is almost 1:1 (no reflected power). This occurs at 31.0 mHz (Band I), 40.0 mHz (Band II), and 54.0 mHz (Band III). This means that when operating at or near these frequencies, almost all of the transmitter power will be radiated as a signal. The VSWR plot also shows that there are points where the VSWR is so high that 33-50% of the transmitted power is reflected back to the transmitter and does not radiate.

The lesson is clear. When engineering radio nets which use the RC-292 antenna as a fixed station antenna, the frequency performance characteristics should be considered. When attempting to cover long distances or large areas (i.e., retransmission or RWI stations), frequencies near 31.0, 40.0, and 54.0 mHz should be used in order to achieve maximum radiated signal. These frequencies should also be used when attempting to power through enemy jamming. When attempting to minimize the possibility of interception and direction finding but still gain the advantages of an elevated antenna, frequencies whose VSWR is high (2.5:1 or greater, 40-50% reflected power) should be used in order to cut radiated signal strength.

The above analysis presently cannot be found in any Army POI or training manual. While the advantages of elevated antennae are mentioned at the Signal Center, the details of RC-292 performance and how to exploit them are not covered. Frequency managers at all levels are not taught much in the way of frequency dependent antenna characteristics and tend to treat all antennae and all VHF-FM frequencies in the same manner. The results of this lack of proper instruction have been:

- Unnecessary use of retransmission stations to extend communications ranges
- Reduced area coverage for both RWI and RETRANS stations
- Increased probability of interception by enemy units
- Increased probability of the enemy locating and destroying the antenna

It cannot be overemphasized that the decisive edge in combat communications and electronic warfare will often be provided by use of subtle techniques like those described above. In order to provide this edge to our combat communications, our operators and frequency managers must be thoroughly trained in our equipment and understand its uses and characteristics. This is the job of our Signal trainers who must assure that our operators know their equipment. Since the RC-292 will remain in our inventory for many more years (until replaced by the OE-254), and since it is the most common VHF fixed station antenna, we should include this information in our field manuals and our training. Some day, during a critical situation, it could provide the decisive edge.

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