

## Return Loss Study of Several Amateur Radio Handi-Talkie Antennas

Andy Palm N1KSN

**Introduction.** This is a study of return loss (RL) for several handi-talkie (HT) antennas. Return loss is the ratio of incident power to reflected power expressed in decibles:

$$\text{Return loss RL (dB)} = 10 \log_{10} (P_{\text{incident}} / P_{\text{reflected}})$$

Since reflected power is always less than or equal to incident power, this is a positive quantity. Some references use the inverse power ratio in the definition, making it a negative quantity. We also have

$$\text{RL} = -20 \log_{10} |\Gamma|$$

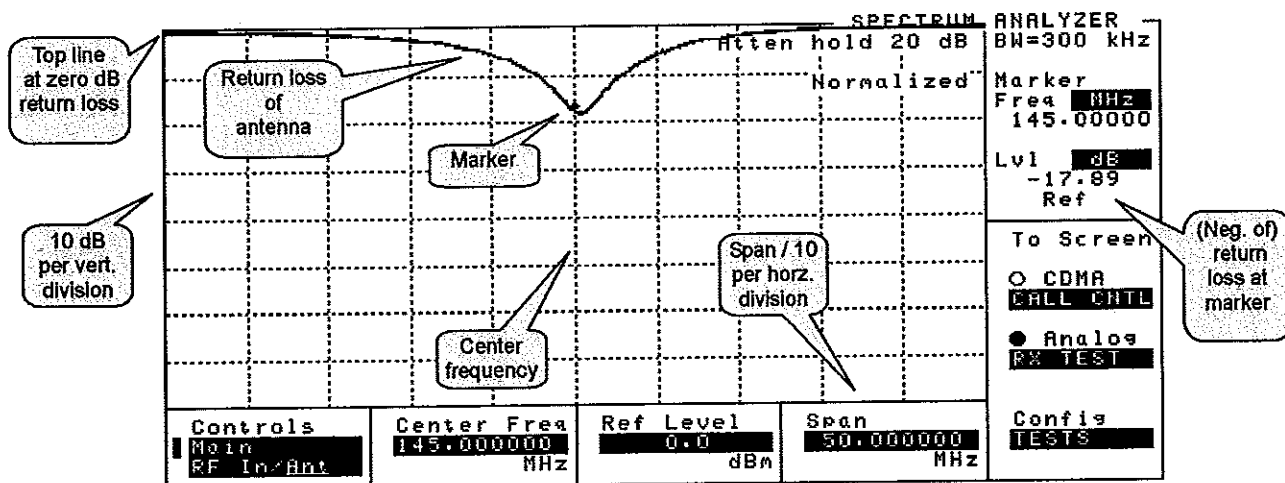
where  $\Gamma$  is the reflection coefficient. This equation connects RL to VSWR (see the table below).

The measurements were done using an Agilent E8285A CDMA Mobile Station Test Set (with the spectrum analyzer and tracking generator option) and a Mini-Circuits splitter, Model ZFSC-2-4, used as a return loss bridge (RLB). The RLB was connected to the Test Set using two Pomona BNC coax jumpers. All antennas had BNC connectors and were mounted directly to the RLB, which was held at eye level about six inches from my face while measurements were made.

The following is an example of an analysis output screen with a key to the main features:

### Smiley Model 68 Stubby Duck

HP E8285A CDMA Mobile Station Test Set: 08/20/10 11:58:00 am



The return loss values (0 at the top line, 10 dB per division downward) can be translated to VSWR with the following table:

| Return Loss (dB) | VSWR |
|------------------|------|
| 5.1              | 3.5  |
| 6.0              | 3.0  |
| 7.4              | 2.5  |
| 10               | 1.9  |
| 15               | 1.4  |
| 20               | 1.2  |
| 25               | 1.1  |

Summary of Results. Measurements were made on twenty-two HT antennas. Ten were two meter only, five were 70 cm only, and seven were dualband. All had BNC connectors.

- ✓ Of the ten 2m only antennas, only four could be considered tuned for the two meter band. All the rest appeared to be tuned for higher frequencies.
  - The Smiley Model 20 5/8 Slim Duck had a broad dip with VSWR  $\leq 1.9$  from 140 to 152 MHz.
  - The Icom IC-T2H stock duck had a more pronounced dip with VSWR  $\leq 1.9$  from 142 to 150 MHz.
  - Icom IC-02AT stock duck #1 had a dip with VSWR  $\leq 1.9$  from 140 to 148 MHz.
  - The Smiley Model 60 Stubby Duck had a dip with VSWR  $\leq 1.9$  from 143 to 148 MHz.
  - Icom IC-02AT stock duck #2 had an out of band dip with VSWR  $\leq 1.9$  from 146 to 156 MHz.
  - The "hamfest special" duck had a dip at the upper end of the band with VSWR  $\leq 1.9$  from 146 to 151 MHz. This antenna is an el cheapo reserved for a fox transmitter.
  - The Radio Shack HTX-202 stock duck had an out of band dip with VSWR  $\leq 1.9$  from 147 to 151 MHz.
  - My homebrew quarter wave antenna had a broad out of band dip centered at about 160 MHz with VSWR  $\geq 2$ . So much for the nominal 19.25" really being one quarter wave on two meters.
  - The Larsen Kulduckie Helical KD-4VHF2 duck had a pronounced dip at around 155 MHz with VSWR  $\leq 1.9$  from 150 to 159 MHz. This antenna would be good for scanning typical VHF public service frequencies.
  - The Larsen Kulduckie 4-146-HQ duck had a dip at 163 MHz with VSWR  $\leq 1.9$  from 155 to 170 MHz. Good for receiving WX stations.
  
- ✓ Of the five antennas for 70cm only, one was especially good, two were good, and two were OK.
  - The Larsen Half Wave (alias "Big Ugly") had a pronounced dip with VSWR  $\leq 1.2$  from 440 to 450 MHz.
  - The Smiley Model 60 Stubby Duck showed a dip with VSWR  $\leq 1.9$  from 422 to 448 MHz.
  - The Smiley Model 20 5/8 Slim Duck showed no pronounced dip, but had VSWR  $\leq 1.9$  across the whole 70cm band.
  - The Icom IC-04AT stock duck was flat across the band at VSWR  $\approx 2.1$ .
  - The Smiley Model 10 Slim Line Duck was flat across the band with VSWR  $\approx 2.3$ .
  
- ✓ None of the dualband (2m / 70cm) antennas showed good tuning on both bands. Some were better on 2m, some were better on 70cm, and some were poor on both bands.
  - Icom IC-T7H stock duck #1 showed a very pronounced dip at 146.5 MHz with VSWR  $\leq 1.9$  from 143 to 148 MHz. But the the VSWR was flat across the 70cm band at about 2.6.
  - Icom IC-T7H stock duck #2 also showed a very pronounced dip but at 147.5 MHz with VSWR  $\leq 1.9$  from 144.5 to 150 MHz. The 70cm behaviour was the same as #1.
  - The Smiley 270A triband had fairly flat VSWR  $\approx 2.5$  on the 2m band with all sections up. With two sections down it had flat VSWR  $\approx 2.2$  from 440 to 460 MHz.
  - Diamond RH77CA #2 had VSWR  $\geq 3$  across the 2m band. Very disappointing, especially considering the price and eHam reviews. It had VSWR  $\leq 1.9$  from 432 to 465 MHz.
  - Diamond RH77CA #1 was very similar to #2, with VSWR  $\geq 3$  across the 2m band and VSWR  $\leq 1.9$  from 436 to 470 MHz.
  - The Nagoya NA-771 had a broad dip around 165 MHz with VSWR between 3 and 2.2 on the 2m band. For the 70cm band the broad dip was at about 430 MHz with VSWR  $\geq 3$  for 440 MHz and up.
  - The Nagoya NA-702 had a pronounced dip at 168 MHz with VSWR  $\geq 3$  on the 2m band. The VSWR on the 70cm band was very high. No more eBay antennas for me.

Discussion and Conclusions. The results were rather surprising in several cases.

- My biggest disappointment was with the dualband Diamond RH77CA antennas, especially their poor match on the two meter band. Given this model's price and high eHam ratings, I expected better.
- The dualband stock ducks for the IC-T7H were disappointing on UHF.
- Don't even ask me about the Nagoya dualbanders. The NA-702 was the worst on UHF.
- As a general conclusion, none of the dualband antennas did well on both bands (although the Smiley 270A was useable). This causes me to wonder just how well any dualband HT antenna performs and perhaps that most dualband HTs are limited by their antennas.
- Of the three Larsen antennas, only the UHF half wave ("Big Ugly") showed a good match (and it was very good). The two 2m antennas from Larsen, supposedly tuned for that band, were not.
- The two Icom IC-02AT stock ducks were not identical in tuning, but at least one of them was good. The stock duck for the IC-T2H was very well tuned for the 2m band.
- The Smiley 2m antennas looked pretty darn good. The Smiley UHF antennas were decent, as well. The 270A triband telescopic wasn't as good, but at least it was flat at "useable" SWRs across both 2m and 70cm bands. I'd have to say that my HT antenna brand of choice is Smiley.
- My "standard" 2m HT antenna will be the Smiley Model 20 5/8 Slim Duck. My 70cm HT will have the Larsen Half Wave on it unless its length is a problem, in which case I'll use the stock IC-04AT duck.
- I'm still uncertain what I will do for a dualband HT antenna.

We should remember that RL or VSWR is only a measure of the match between the transmitter and the antenna indicating how much of the available power gets into the antenna. The antenna radiation pattern is also important, and other things being equal (or nearly so) a longer antenna will have a larger capture area for better receiving.

Given the results of this study we can also draw a couple more general conclusions:

- Most handi-talkie power amplifier sections must be built to withstand considerable mismatches with the antenna. But one has to wonder if at least some of the heating of HTs at full power many hams complain of might be due (at least to some extent) to the poor matches some antennas have.
- Hams are probably radiating a lot less power than they think they are when using their HTs. We should be grateful for our repeaters!

Supplemental Summary of SMA Results. Measurements were made on six SMA HT antennas, all dualband. The results for the previously measured Smiley 270A are repeated here since this antenna is available with an SMA connector.

- ✓ The results were similar to those for the B NC antennas. None of the antennas showed a good match on both 2m and 70cm.
  - The Icom IC-Q7A stock duck had a pronounced dip but with VSWR  $\leq 1.9$  from 146.5 to 149 MHz. It had flat VSWR  $\approx 3.4$  across the 70cm band.
  - The Diamond SRH519 duck had a dip with VSWR  $\leq 1.9$  from 145.5 to 149 MHz. On 70cm the VSWR was 3 or worse across the band.
  - The Nagoya NA-773 had VSWR  $\geq 3$  across the 2m band and from 440 to 450 MHz..
  - The Diamond SRH77CA was very similar to the BNC Diamond RH77CA #2 with VSWR  $\geq 3$  across the 2m band and with a UHF dip giving VSWR  $\leq 1.9$  from 437 to 474 MHz.
  - The Comet SMA-24 had a broad dip at 157 MHz with a VSWR of about 2.5 at 144 MHz and decreasing to around 1.9 at 148 MHz. It had a broad dip around 410 MHz with VSWR  $\geq 3$  from 440 to 450 MHz.
  - The Smiley 270A triband had fairly flat VSWR  $\approx 2.5$  on the 2m band with all sections up. With two sections down it had flat VSWR  $\approx 2.2$  from 440 to 460 MHz.
  - The Maldol MH-209 SMA had a pronounced dip at the top of the 2m band, with VSWR  $\geq 3.5$  at 145 MHz. It had a broad dip at 442 MHz with VSWR  $\geq 2.7$  across the 70cm band.

Supplemental Discussion and Conclusions. These results were unfortunately very similar to those of the previously tested dualband antennas.

- ✓ With two exceptions, the SMA antennas had a VSWR of 3 or higher on at least one of its two bands, namely:
  - The IC-Q7A stock duck, Diamond SRH519, and Comet SMA-24 were useable on 2m but had VSWR at 3 or higher on 70cm.
  - The Diamond SHR77CA had a good match on 70cm but had VSWR  $\geq 3$  across the 2m band.
  - The Nagoya NA-773 had VSWR  $\geq 3$  across both bands.
- ✓ The Maldol MH-209 Stubby Duck had a dip for each band, but the 2m dip was at 148 MHz making it a decent match only on the upper part of the band. On 70cm the dip was well placed in the band, but the VSWR was marginal, at best.
- ✓ Only two dualband antennas, the Smiley 270A and the BNC IC-T7H stock duck, were acceptable on both bands.. All other dualbanders were good for at most one band.