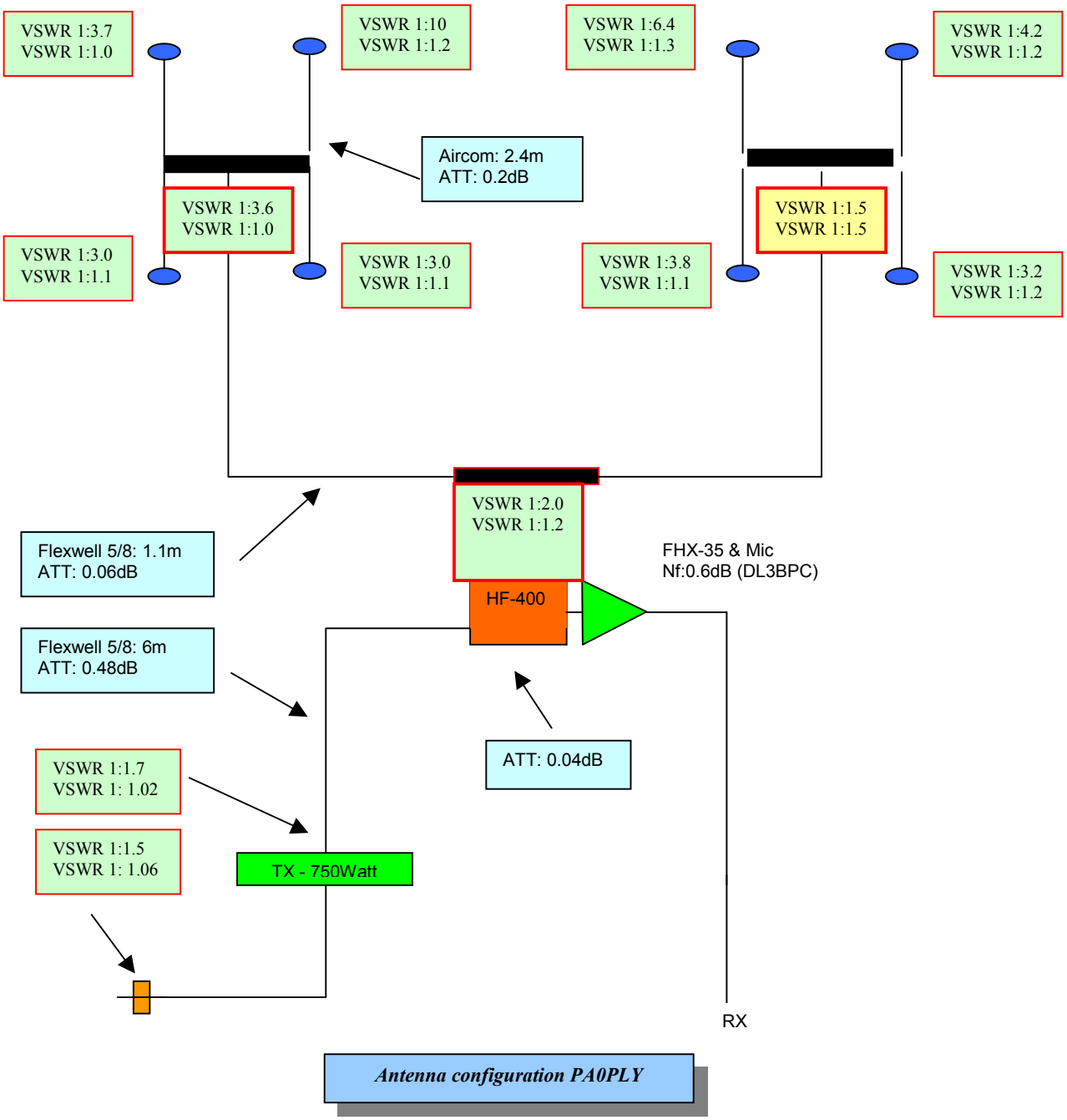
The VSWR Saga

Optimising your antenna is a good task to improve your readability of signals. Particular adjusting the standing wave ratio (VSWR) will help a lot for the transmit part of your system.
It might help for the receiving side as well, but not necessarily, since it depends on the characteristics of the pre-amp and the fact that low noise figures is almost a synonym for high VSWR ratios
The VSWR is the ratio between forward and reflected power a shown in below formula:

$$VSWR = \frac{1 + SQRT(RFL/FWD)}{1 - SQRT(RFL/FWD)}$$

In amateur terms a VSWR of 1: 3 represent a factor of 25% reflected power.
Keeping the VSWR below say 1: 1.5 ensures only 4 % is returned from your antenna.
So far most radio ham's will have identical experiences. It turned into a different story when I set-up my 8 x EME Yagi system, using 3 couplers.
Carefully adjusting each antenna prior to final mounting showed a good VSWR down in the shack for the entire array.
However after some period of time I found stations became weaker and weaker. However the amount of reflected power from my array did not ring the alarm bells.
A 400mW in stead of less then 200mW with 20Watt of forward Rf power seemed reasonable for me.
Since the situation didn't improve of the period of time I decided to inspect each individual antenna. Spending a day on the roof, of course in the wintertime, is not my favourite free time stay. I found the hairpins were rusted and some of the dipole boxes were poured with water. Since it was impossible to measure each antenna's VSWR, I decided following alternative method.
Disconnect one antenna; use a long piece of coax and measure the amount of RF power, at the coaxial cable end, which was initial connected to the antenna. This ensures the couplers are well working. After replacing the hairpin, the dipole box was re-installed and VSWR was checked for improvement.
Although this procedure did result in little improvement, it did not return the good values gained at the time the array was erected for the first time.
Since the springtime arrived a scaffold was erected aside the mast for easy assessment to the entire array.
Now I was able to measure the VSWR for each antenna while mounted in the mast. To see what actually happens I executed VSWR measurements are various locations in the entire chain of coaxial cables down to the Power amplifier as well as to the transceiver location.
The results were dramatically at each antenna, but not at the feed point down in the shack!
That's why I decided to publish the results of spending many hours to complete the measurements and re-adjustments of my antenna's
Below you find an overview of the VSWR figures measured. While figures at the feed are not dramatically, the individual antenna's are really bad.
Now each antenna was re-adjusted for best VSWR value. Both the hairpin and the dipole length were adapted for this case. From this experience, it turned out, that particular the length and thickness of the hairpin contributes to a good VSWR. Final results are show in the figure as well.
As a final conclusion. It can be said that in multi-antenna array's, one should pay extremely good attention to its VSWR in the shack. Each little change may be an indication of some dramatically change somewhere up there.
In my case it was caused by replacing hairpins with different diameter and no ability to check out each antenna at that time.
Again, after this experience and spending a lot of time for correction, I have confidence with my antenna array but will keep sharp eye's on reflected power changes. Particular using more couplers in the chain between an antenna and the RX/TX location seems to hide those bad conditions.


VSWR 1:3.7
VSWR 1:1.0
VSWR 1:10
VSWR 1:1.2
VSWR 1:6.4
VSWR 1:1.3
VSWR 1:4.2
VSWR 1:1.2
Aircom: 2.4m
ATT: 0.2dB
VSWR 1:3.6
VSWR 1:1.0
VSWR 1:1.5
VSWR 1:1.5
VSWR 1:3.0
VSWR 1:1.1
VSWR 1:3.0
VSWR 1:1.1
VSWR 1:3.8
VSWR 1:1.1
VSWR 1:3.2
VSWR 1:1.2
VSWR 1:2.0
VSWR 1:1.2
Flexwell 5/8: 1.1m
ATT: 0.06dB
FHX-35 & Mic
Nf:0.6dB (DL3BPC)
HF-400
Flexwell 5/8: 6m
ATT: 0.48dB
ATT: 0.04dB
VSWR 1:1.7
VSWR 1: 1.02
VSWR 1:1.5
VSWR 1: 1.06
TX - 750Watt
RX
Antenna configuration PA0PLY