1W @ 531kHz MW Station System

(8 Bit ASCII graphics use code page 437 or 850, Terminal Font)

Hi Readers, (Updated Sep 11)

A few years ago I & several other hams did the engineering on 6 one month MW U.K. Restricted Service Licence broadcasts on 531kHz. The 565m wavelength is more than 3x that of topband, so you may like to know more, especially as there is a 500kHz experimental UK ham band now.

Only vertical polarisation is used for MW broadcasting, as all domestic Rx are vertical (vertical car aerials & horizontal Rx ferrite rods), so horizontal radiating aerials are of no use! Also there is a severe restriction on RSLs, that limit the aerial height to only 20m at this frequency, so to get a good 1W MONOPOLE ERP is not at all simple.

This is how we did it...

THE AERIAL

We used a modified inverted L design that was suitable for our site, it has a 45° sloping vertical underneath the top section. This proves very effective with next to no horizontal polarisation component radiated.

```
Very_            3   S p r e a d e r s                              _,Very
Tall 'Ropes  2m            1m           0.5m                        Rope  Tall
Tree      ''===========================================-------------'      Tree
             \\\\\       2x 90m of 2.5mm 7 stand Cu.      Twisted
               \\\\\          Mean height 20m
                 \\\\\
  10x 28m of 1.5mm \\\\\
     7 strand Risers \\\\\
      all 20cm spaced  \\\\\
       & sloping at 45°  \\\\\ (
                          ---->( Tapped  (5mm dia tinned Cu wire)
                            │  ( Large   (20 Turns 15cm dia)
               8mm Spark Gap   ( Loading Coil
                            │  (
      50m UR67 ==============──┤
                            │ ─┴─ 3nF
                            │ ─┬─ 1kV  15 BONDED
                            │  │       EARTHING
                           ┬│┬┬│┬┬┬┬┬  STEAKS
```

The 2 top wires are tied off in tall trees, really taught at 40kg tension. The 10 slopers use thinner 7 stranded wires to carry the current (as we had plenty of that wire available). We used 3 plastic 5cm pipes as spacer bars for the risers & 3 weight stabilised top spacer triangles. e.g. __ to stop the to pair
twisting. \/

TUNING & BANDWIDTH

Loading was done with a large tapped series L & with 3nF across the coax. The tapping point (copper strip with wires attached) is moved up, down & around the coil around until the return loss is > 35dB (SWR 1.04:1) is found. Then the tapping point is soldered on to the coil & retested. Normally there is some frequency offset of a few kHz to this process, but dressing the earth & aerial wire either side of the coil, fine tunes the aerial system to get this well centred graph...

```
                  A M  S I G N A L
              | \      Carrier      / |
              |   \       |       /   |
VSWR          |     \     |     /     |
2.0:1- .      |       \   |   /       |    .
1.8:1-  `\    |   LSB   \ | /   USB   |   /
1.6:1-    `\_ |_______________________|_/'
1.4:1-       `._                    ,-'
1.2:1-          ` -... _     _ ...-'  Measured
1.0:1-                   """            SWR
     +-+---+---+---+---+---+---+---+---+---+--
     521 523 525 527 529 531 533 535 537 539 kHz
```

Tuning is very critical & only a narrow aerial bandwidth of ±6kHz is possible, up to an SWR of 1.5:1, but this is just about OK for Broadcast AM.

The Tx AF system we used is very flat 10Hz - 6kHz ±1dB, but > -40dB @ 9kHz to meet the broadcast spec. Treble around 5-7kHz will produce phase modulated sidebands on this aerial, reducing the effective AM modulation depth!

EARTHING SYSTEM

```
               *---------*
R ===|S'  ·  /,  \      /  \
I ===|P    /    ' *---*      \
S ===|A  /       / \ / \· .    \      [@] = Loading coil in box.
E ===|C *----[@]*---C---*---R---*       C = Centre stake, 1.5m 22mm Cu pipe
R ===|E  \       \ /.\·/ '     /        * = >1M 22mm dia Cu Earth pipes
S ===|R.  ·\   '  *---*      /        \/- = Joining wires
             \  /       \  /            R = Rope tie point 1.5m Cu plated steel
               *----------*           .·' = Rope to spreader.
        <- - - - - 5m - - - - ->
```

This uses 14 short copper pipes in 2 circles. We found that adding any more did not alter the aerial Z at all! Also adding long counter poises had no detectable effect to the aerial Z either. I think this was due to the wet ground conditions 1m underfoot! Putting a few kg of salt around the copper rods (not on the connections!) may have also help keep the earthing losses low in dryer summers.

AERIAL EFFICIENCY & ERP

```
               |
               |
        1/4    |  IDEAL
        Wave   |  REFERENCE            AERIAL USED TO
               |  AERIAL               THE SAME SCALE
               |                             ___          2% efficient
_______________|_______________    ___________\___________     Maximum!
///////////////////////////////           ///          + other losses
Good Cu Ground Mat Over at least         Small earth
  Quarter Wavelength Radius
```

As the aerial height was only 1/7 of a 1/4 wave tall, the maximum aerial gain is in the order of 2% (1/7 x 1/7), (-17dBi) as it was only base loaded. This figure is very close the radiation resistance method of calculation that gives 2.9%. But really the true aerial efficiency is all about ground surface resistance at the frequency over something like 10 wavelengths radius (5km) & not just at the Tx site!

FIELD STRENGTH MEASUREMENTS
As with all aerials, there is near field (cube law) component not square law, & this will be much stronger for the ERP with a tiny aerial like this, than it would be with a full size quarter or half wave aerial. This is due to the "transformer action" (like local CRT TV line timebase QRM etc,)

N.B. A point source radiator has infinite electric & magnetic fields, but not at 90° & hence it has NO ERP!

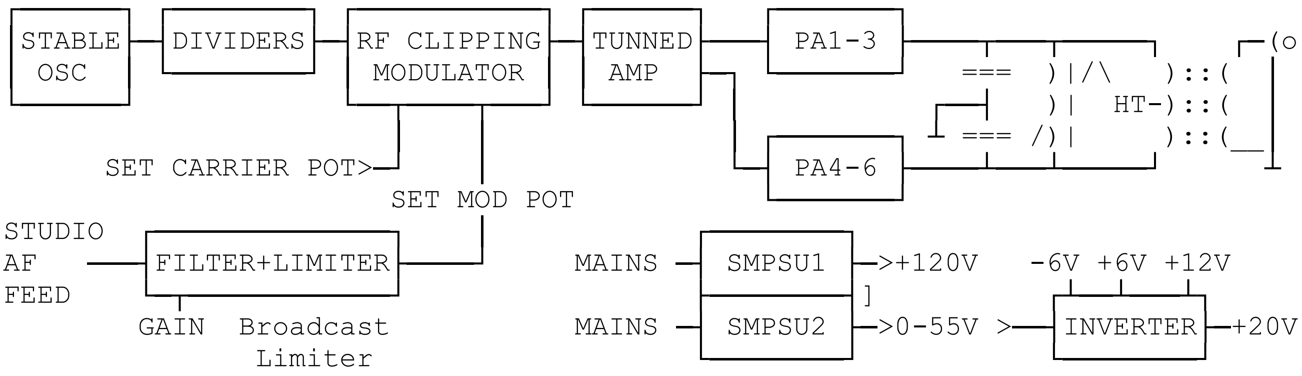
This near field, has the effect of uncalibrating field strength measurements for ERP calculations locally (under 10 wavelengths), so local magnetic only field strength measurement method is not very accurate for estimates of the real ERP. The method is useless unless a -6dB/distance doubling, can be shown to be true.

Also affecting the field strength at our site are large variations in the terrain type over the first few wavelengths (e.g. wet clay valley & 3 nearby dry chalky hills). These one would expect to affect the radiation resistance of free space (377Û) near to the ground. Of course in free space at >10 wavelength away, the field strength measurement would be accurate for estimating ERP.

Both the Aerial & Tx system have been technically inspected by the regulator Ofcom & were all OK, & the system radiated near the correct ERP when measured at a distant calibrated site.

THE TX
This is a large old DECCA Beacon 80002A LW MCW aircraft navigation beacon Tx, pushed up to work on the edge of it's frequency range at 531kHz. It is only capable of about 400W PEP max, above that it was totally non linear for AM. (The PA is OK for non linear CW @ 800W on LF to produce 10W ERP into short aerials!)

About 50W of AM carrier was needed for the 1W ERP station. The broadcast modified Tx uses a temperature controlled Xtal Osc, to a low power AM exciter stage with diode clipping of the RF for give the AM envelope, this feeds a 1W tuned class A stage which then feeds split phase into 6 large class B DC coupled amps pairs with NFB in push pull (36 TO3s in all), to an iron dust core output transformer. Across this is a large permeability tuned L (6 movable ferrite rods) that resonate the 24 caps across each PA transistor.



The original 2 HOT linear PSUs were 55V + 65V @ 4A, 12A peak (800W CW mode), are superseded now by two 2nd hand SMPSU ones that run cold, & reduce unwanted shack heating!

EFFICIENCY & MODULATION
Although a very inefficient Tx design (10% at 50W on 531kHz) compared to high level AM mod, it does do very good bass & has linear phase down to a few Hz. This is because there is no modulation transformer or LF choke to give LF phase error. This is very important when used after an AM broadcast limiter that adds small amounts of near DC LF components, so this design does not change the wanted modulation waveform at all. Only efficient PWM systems are as good.

As the low level AM modulation stage can't produce 100% modulaton (always some carrier left), the class B PAs are left slightly under biased in this design. This results in good deep carrier cuts on over modulation. But when set up properly with the broadcast limiter, near 100% modulation peaks are maintained at near clipping all the time, keeping the AM channel full of deep modulation & adjacent channels clear of over modulation splatter.

HARMONICS
With this frequency the 2nd & 3rd harmonics are actually in band (MW)! With this Tx harmonics are > -60dBc & with the high Q of this aerial system, results in them being further suppressed to approx. -100dBc. They actually can't be detected over sky noise 400m away from the aerial!

1W ERP RANGE @ 531kHz
At this frequency it was found the ground wave coverage was about 60-90 miles (100-150km) with a good normal Rx but only 8 miles 14km @ night due to QRO QRM from 3 100kW co-channel stations.

With a comms Rx with RF quiet loations >400 miles (700km). e.g. we have Rx Dx reports from Finland, Italy, N.Scotland, Channel Isle etc. This seems extreme DX for a QRP MW station, but these reports are not really at a good listernable strength.

The range would only be 1/3 of this at the other end of MW range on 1593kHz, & give only 1/9 of the coverage area, a point possibly missed by the licensing regulator! Aren't the laws of physics wonderful.

However QRM from any SMPSU, PC Screens, TV timebase, Broadband phone cabling, & Fluorescent lamps, can easily wipe out a weak MW signal on this frequency.

Also see my bul on "AM Broadcast Radio Principles".

Why don't U send an interesting bul?

73 de John G8MNY @ GB7CIP
/EX