Felix Elsen
Kapelstraat 46, B-3212 Pellenberg, Belgium
felix.elsen@gmail.com

Amateur Radio Station
on6be

SAQ fieldstrength calculation v.1.0

Date: 03/03/2013

1 Introduction

An attempt has been made to calculate the emitted radiated power (ERP) from radiostation SAQ @17.2 kHz (Grimeton).
Fieldstrength is measured in Belgium at a distance of about 850 km to Grimeton.
We will introduce the methods as described in ITU-R to calculate.
Electrical fieldstrength is measured with an active rod antenna at a measuring height of 4m above ground.
My location is on top of a hill at 100m asl..
Let me underline the accuracy of these calculations is limited. It starts already with the accuracy of measuring the E or H field. Currently I use active rod E antennas which are difficult to calibrate. A magnetic antenna could be calibrated pretty accurately though. Further, there is the factor of ground conductivity which is mapped but still only a rough guideline.

2 Inputs

SAQ own estimation of ERP = 10kW (unclear at what generator power level, I assume max power 200kW)
Estimation by Arthur D.Watt (book VLF Radio Engineering, page 125) = 8 kW (SAQ running at max power)

Measured fieldstrength in Pellenberg, Belgium = 59.7 dBuV/m (12/07/2011 measured)
Distance to SAQ = 853 km
Ground conductivities for VLF are extracted from ITU-R. 832.2.
Soil condition: 4/5 of the path travels over land with - conductivity = 0.01 S/m
- epsilon = 30
1/5 of the path runs over sea (salt) water with conductivity of 4S/m

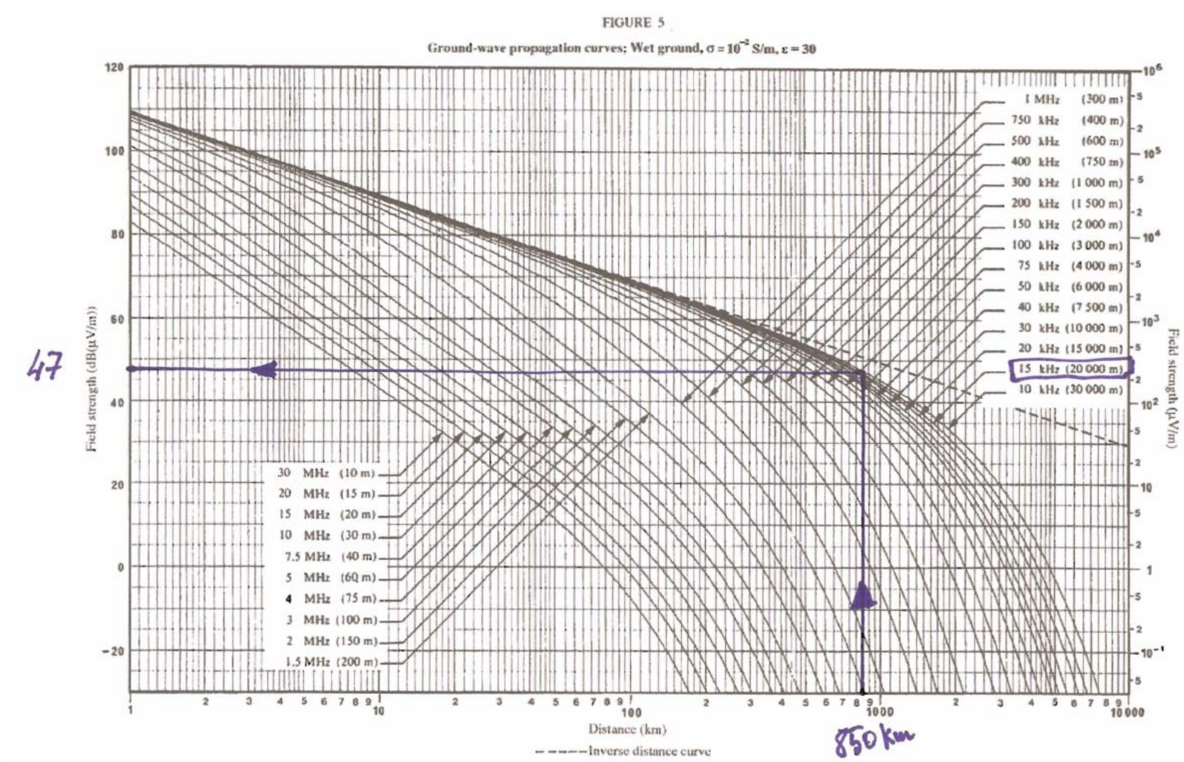
SAQ used power level is unknown (said to run at much lower power as 200kW, possibly around 80 kW)
Radiating resistance, loss resistance, ground resistance of the antenna is unknown.
Antenna is a 6 element Alexanderson antenna, efficiency unknown. Antennas of this era (1920's) are typical around or below 20% acc. to the book of Mr Watt.

3 Which calculation method to use

ITU has 2 methods in use for propagation estimates: one based upon groundwave propagation only (ITU-R.P 368-9) and one based upon groundwave + skywave reflection (ITU-R.P 684-5)
The last one is to be used at larger distances from SAQ where at least one hop is involved.
Since the troposphere condition changes with the month, sunspot no and time, calculated values change over the day and season.
The lower the frequency, the lower is the effect of skywave propagation. It is seen in ITU-R.P literature there seems to be some gradual transition point at around 30 kHz. So actually at 17.2 kHz and for my distance of 850 km the effect from the skywave reflection should be minor.
There are some other calculation softwares, for example from NICT Japan, however they are for > 40kHz.
In this document I have also used the ITU-R.P calculation software as public available on their website.
.

3.1 Calculation acc. groundwave only ITU-R.P 368-9

We have used the graph as supplied in the standard for 0.01 S/m and ξ= 30.
The graph indicates a fieldstrength of about 47 dBuV/m for 1 kW ERP (normalized value).



We measure 59.7 dBuV/m (measured 12/07/2011) which is (59.7 – 47) = + 12.7 dB,
When we add this on top of 1 kW we come to 1 * 10^1.27 = 18.6 kW

Or a power of 18.6 kW EMRP (effective radiated monopole power)
Or a calculated power of 5 * 1.83 = 34 kW ERP

Note that acc. ITU_R.BS 561-2 the ITU graphs are referring to EMRP and not to ERP.

The values from the table above are supported by the ITU calculation program “grwave” which we output below. The output is also referenced to 1 kW EMRP.

```
GRWAVE COMPUTES FIELD STRENGTH-DISTANCE VARIATIONS
FOR A HOMOGENEOUS CURVED EARTH WITH EXPONENTIALLY
DECREASING REFRACTIVE INDEX

          ATMOSPHERIC CONSTANTS
             REFRACTIVITY =315.00  (N-UNITS)
             SCALE HEIGHT = 7.350  KM

          GROUND CONSTANTS
             RELATIVE PERMITTIVITY =    30.000
             CONDUCTIVITY =1.0000D-02  SIEMENS/METRE

          VERTICAL POLARISATION

          MINIMUM DISTANCE =   500.000  KILOMETRES
          MAXIMUM DISTANCE =  1000.000  KILOMETRES
          DSTEP          =    50.000  KILOMETRES


          FREQUENCY =     .017 MHZ

          TRANSMITTER HEIGHT =      .0  METRES
          RECIEVER HEIGHT    =     4.0  METRES

          DISTANCE      FIELD STRENGTH     BASIC TRANSMISSION LOSS
            KM           DB(UV/M)             DB          (F)
                                             (R)
            500.00       53.65              52.94
            550.00       52.54              54.05
            600.00       51.47              55.12
            650.00       50.46              56.14
            700.00       49.48              57.11
            750.00       48.54              58.05
            800.00       47.63              58.96
            850.00       46.74              59.85
            900.00       45.87              60.72
            950.00       45.02              61.57
           1000.00       44.19              62.40
Stop - Program terminated.
```

3.2 Calculation acc the free space formula

The book “VLF Radio Engineering” highlights a formula 2.1.8 (page 17) for calculating the fieldstrength for the “monopole” case of the transmitter (so not the isotropic case).

E (mV/m) = (300 * P^0.5) / d   P in kW EMRP
                                                        d in km

This is for the full free space condition. As can be seen from the ITU curves, due to the ground condition we need to add some more power due to the 3 dB fieldstrength loss. Therefore, we calculate with 59.7+3 = 62.7 dBuV/m fieldstrength. This compensates for the ground loss.

62.7 dbuV/m = 1.36mV/m
d = 853 km

P = (853 * 1.36 / 300)^2
P = 15 kW EMRP