VLF Amateur Radio

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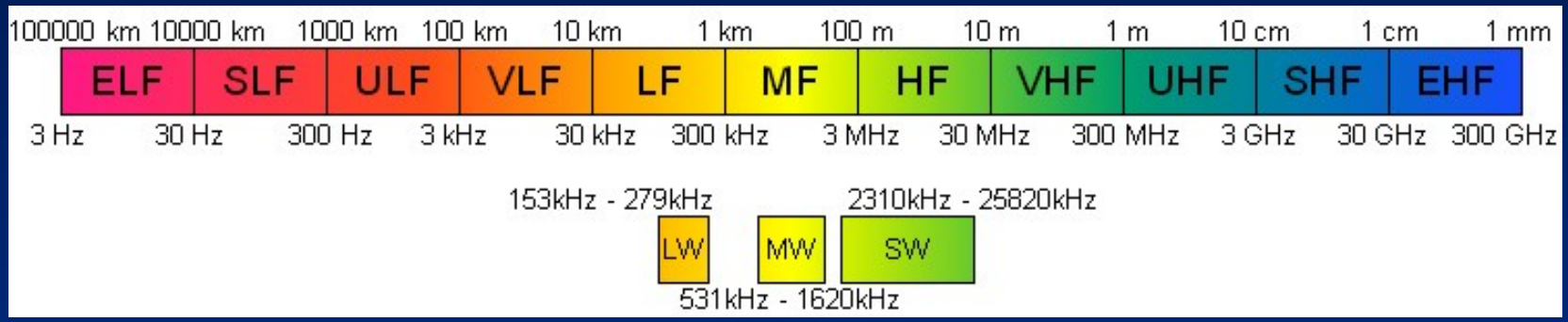
Topics to cover

- The VLF spectrum and its uses
- Equipment needed for VLF RX and TX
- VLF earth-mode through-ground tests
- VLF 8.97 kHz *radiated* DX
- Getting involved – it's simple and inexpensive.

The Sub-9kHz VLF Spectrum



- Wavelengths are VERY long below 9 kHz.
- VLF TX antennas are huge.
- Signals go through water and rock better.
- Bandwidths are narrow – data modes only
- Reliable world-wide range, with enough power

VLF/ULF/SLF Users

Mainly the military (submarine comms + navigation):

- 14- 30 kHz Military MSK and time signals
- 11-14 kHz Navigation systems (Alpha/ old Omega)
- 8-9 kHz Sferic detection systems
- 1-8 kHz Natural emissions detection
- 50-90 Hz Submarine comms (ZEVS/Sanguine)
- 50/60 Hz Power distribution

Amateur VLF

- 8.97 kHz being used for tests in Europe
- Earth-mode* tests between 0.8 kHz -17 kHz
- 8.7-9.1 kHz allocated to UK amateurs by NoV

** ….an explanation later*

Modes for VLF

- QRSS3, 30, 120, 6000 = Slow CW mode
- DFCW = Dual Frequency CW
- WSPR
- Continuous carrier (for days!)

Receiving VLF signals

- High man-made and natural noise
- 9 kHz LF/MF signal intermodulation QRM
- Big antennas not needed on RX
- Equipment is simple to build
- Free software available to help detect weak signals

VLF Receivers

- Sub-9 kHz signals can be directly detected and fed into phones or PC. No need for up-converters and HF RX.
- PC used for filtering and weak signal processing
- Main issue is dynamic range and S/N
- Need an E-field probe or a loop
- Need a preamp with good dynamic range

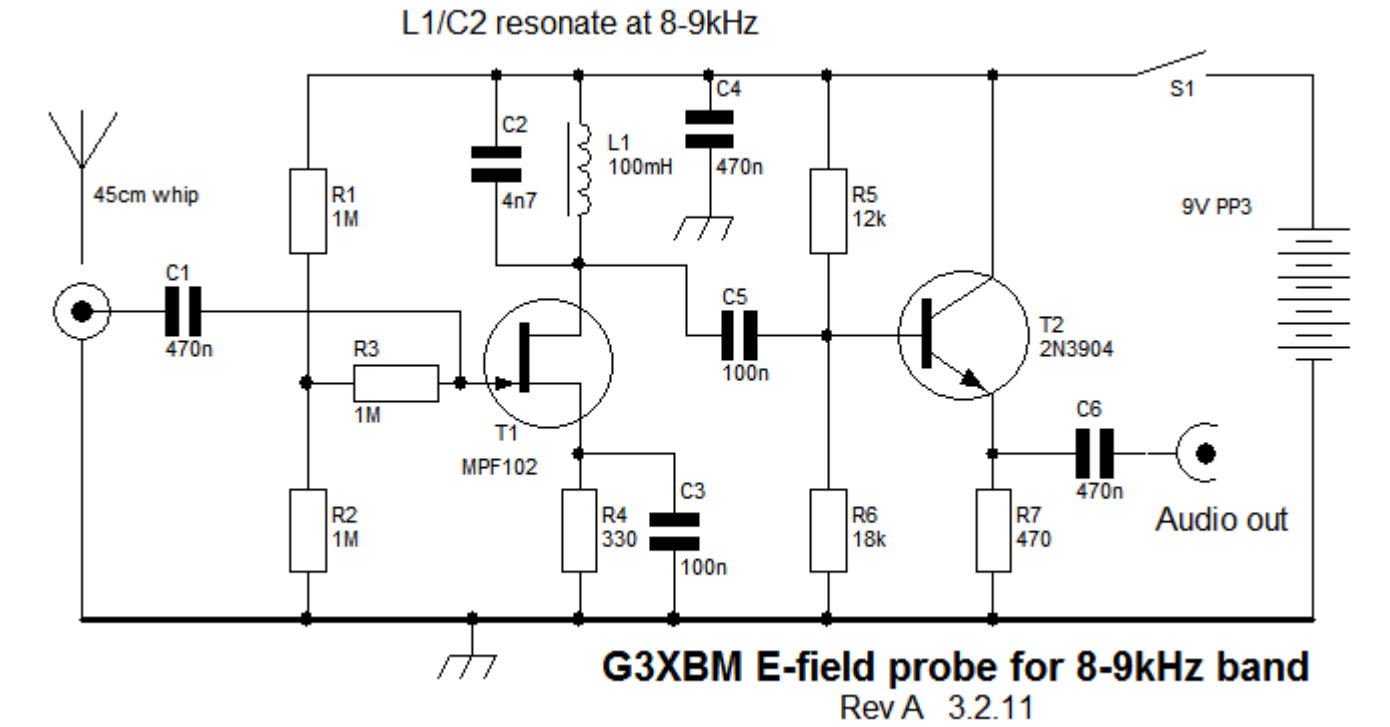
VLF RX Loop Antenna

- 80cm, 30turn tuned loop
- Hand carried/rotated or placed on ground
- For home use a large vertical 1t wire loop OK

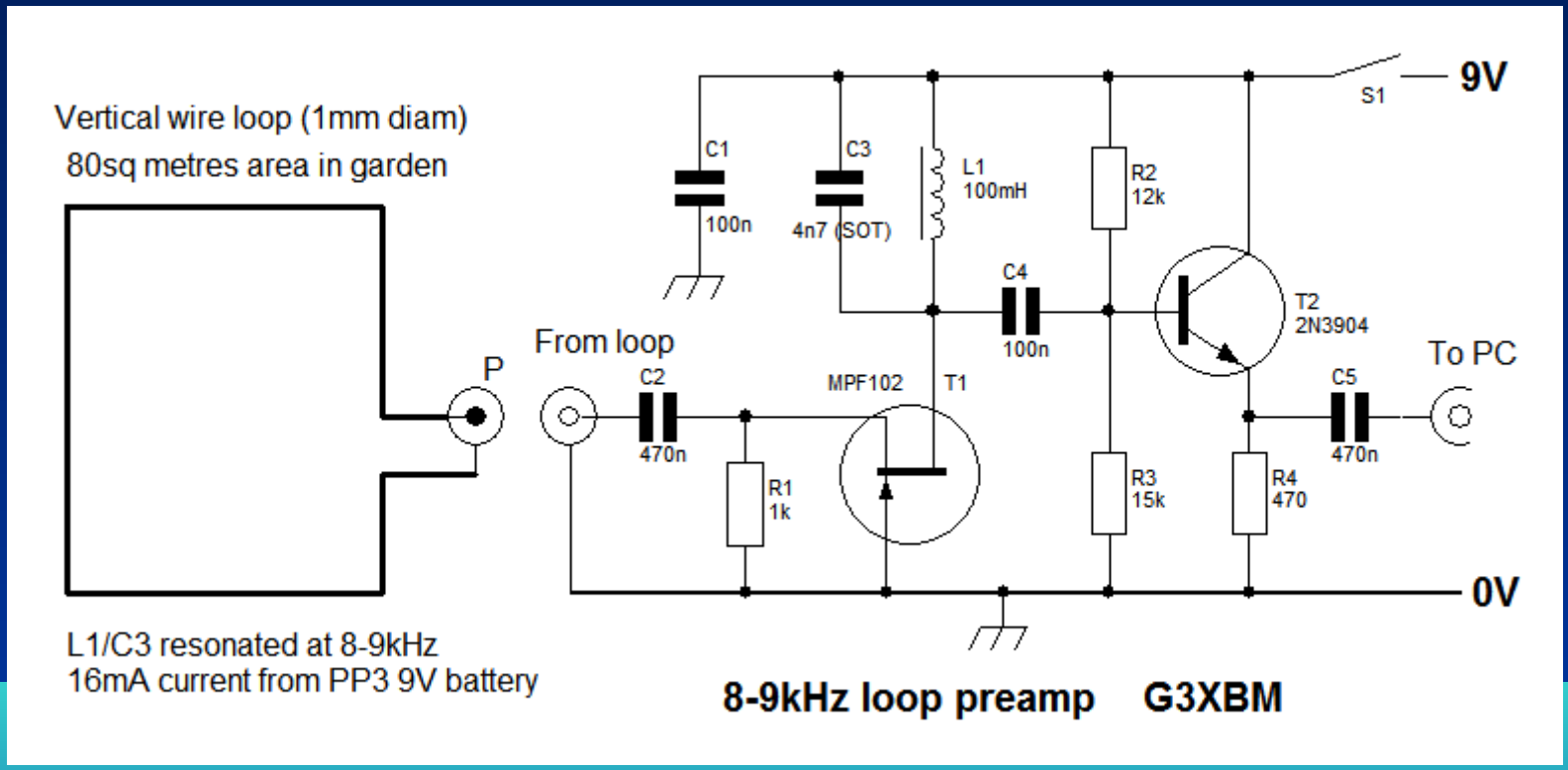
VLF Preamp

- Built in a small box
- Powered by rechargeable 9V battery
- Inexpensive

VLF E-field probe



VLF loop preamp



Earth Electrode “Antenna”

- Earth rods in ground 20-50m apart

or

- One earth rod + connection to house metal water pipes

VLF PC Software

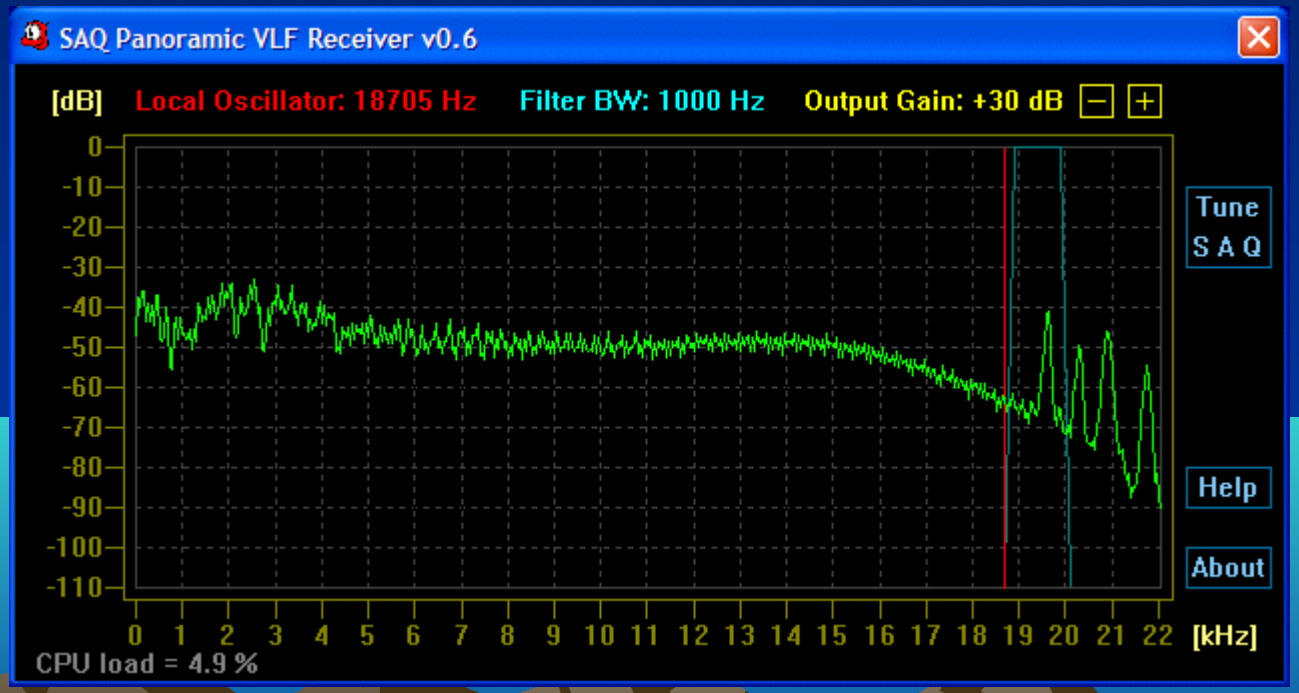
Needed to detect VERY weak, long duration signals deep in noise

- SM6LKM's tuneable VLF receiver program
- Spectran
- Spectrum Laboratory

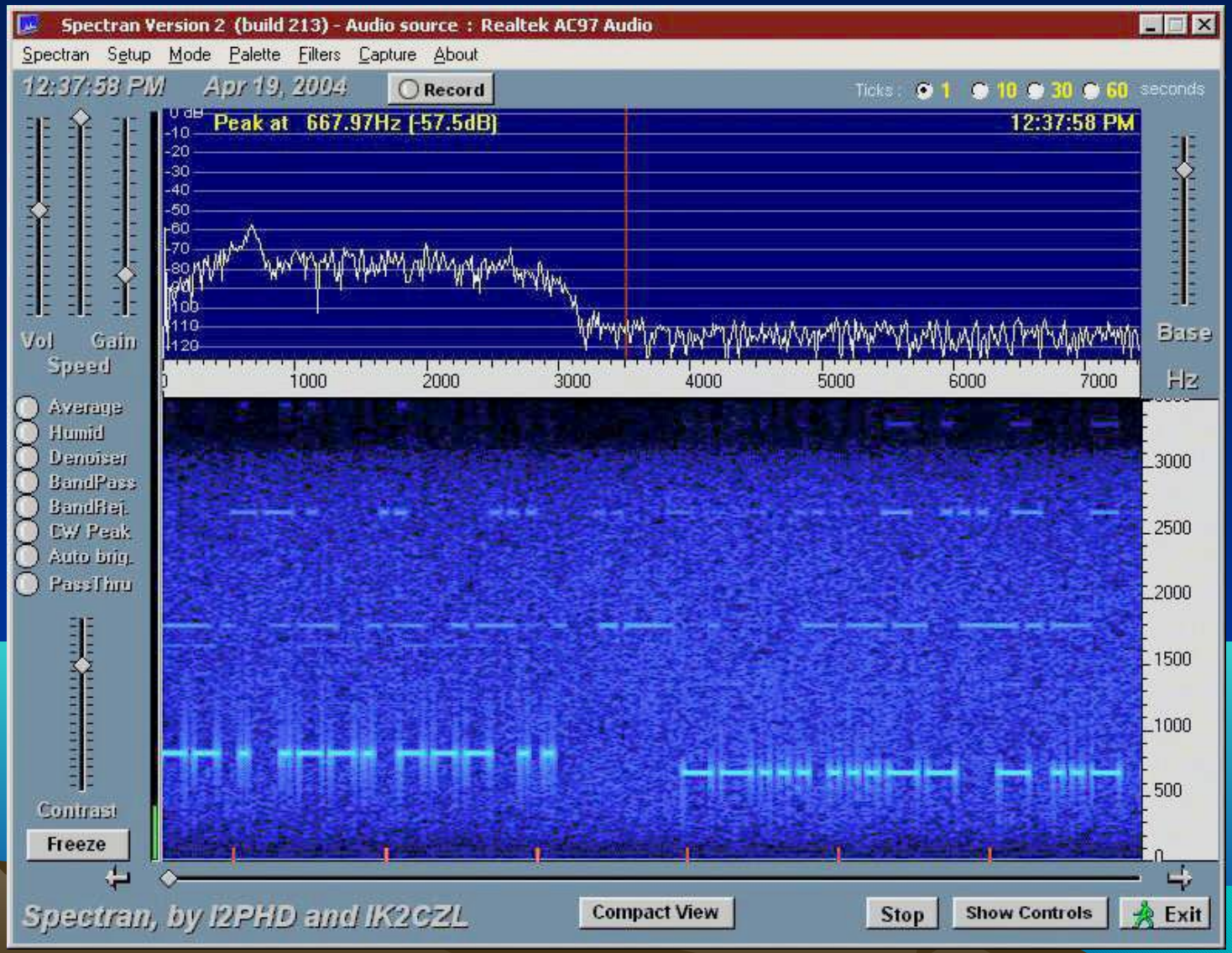
All are free

SM6LKM's VLF Receiver

- Runs on PC
- Just needs input from antenna/preamp
- Tunes 0-22 kHz with mouse



Spectran


Spectran Version 2 (build 213) - Audio source : Realtek AC97 Audio
Spectran Setup Mode Palette Filters Capture About
12:37:58 PM Apr 19, 2004
Record
Ticks: 1 10 30 60 seconds
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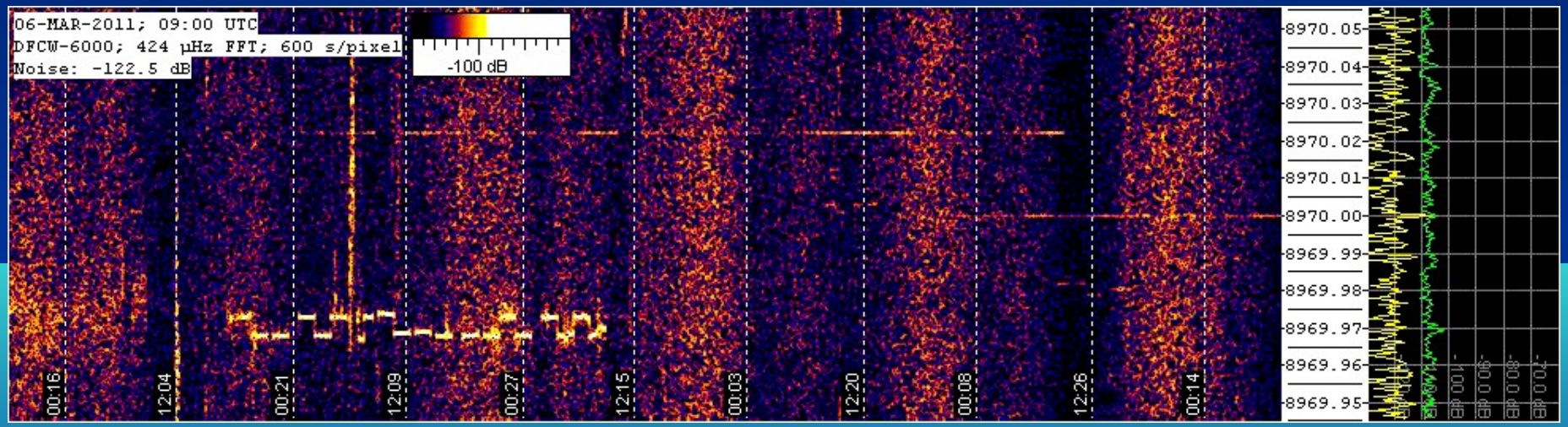
BandPass
BandRej.
CW Peak
Auto brig.
PassThru
Contrast
Freeze
Spectran, by I2PHD and IK2CZL
Compact View
Stop
Show Controls
Exit

Spectrum Laboratory

- Complex and powerful program
- Plots spectrum view of signals received
- Allows reception for days in very narrow bandwidths

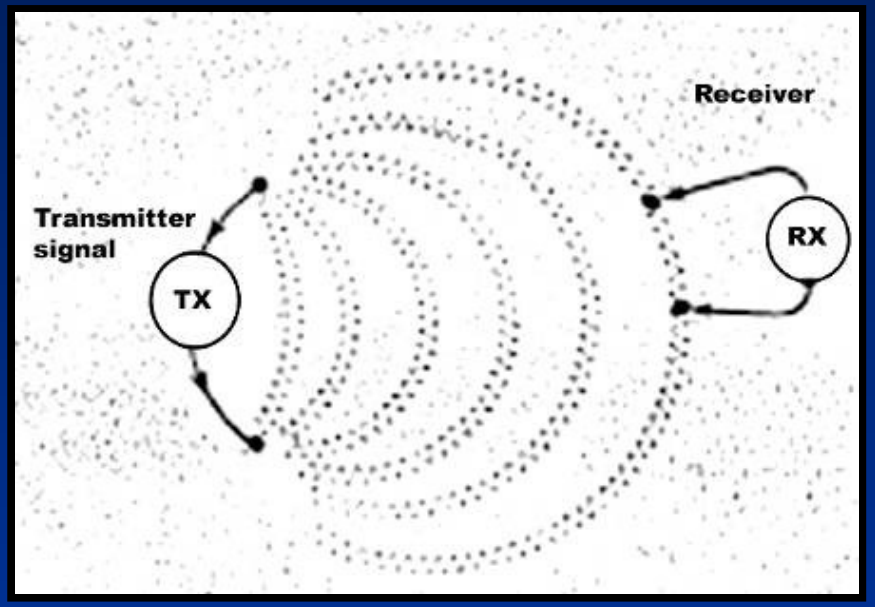


What is “Earth-mode”?

- Communicating through the ground via conduction/induction
- Signals attenuate very rapidly (inverse cube law)

Earth-mode Concept

- VLF signal injected into the ground or water
- Detected as a weak potential difference (or H field) at a distant point
- Conduction or induction?
- Some question theoretic explanations



Earth-mode Transmitter

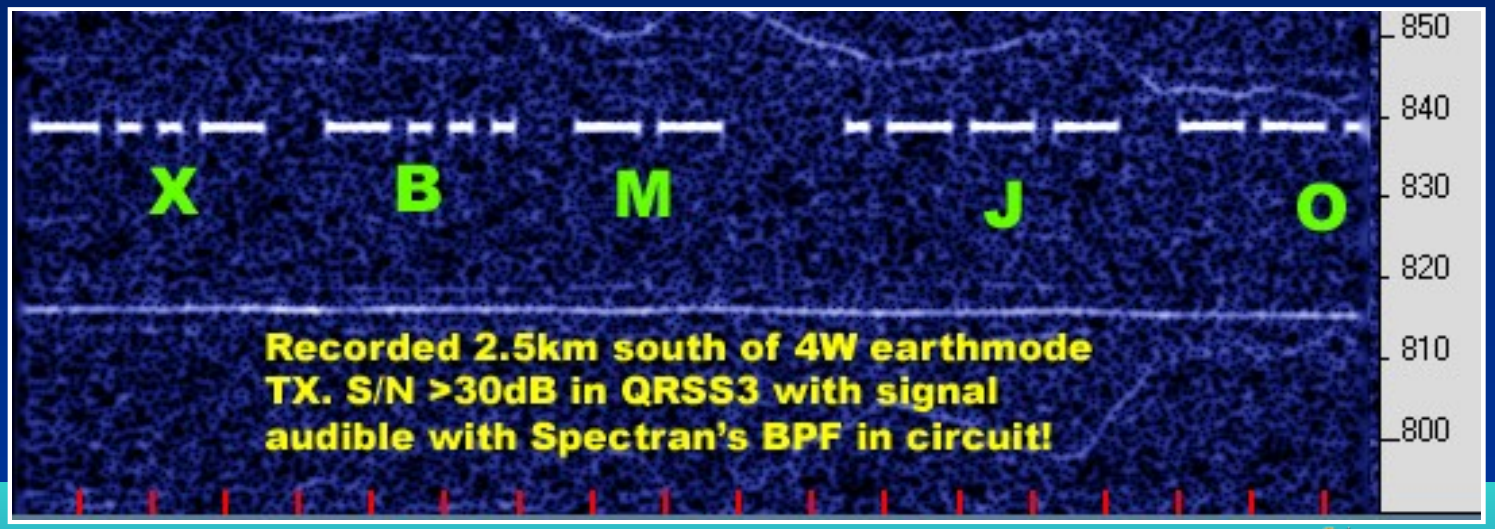
- HF crystal/divider
- K1EL keyer IC
- TDA2003 5W PA
- VLF ATU

My Earth-mode Test Method

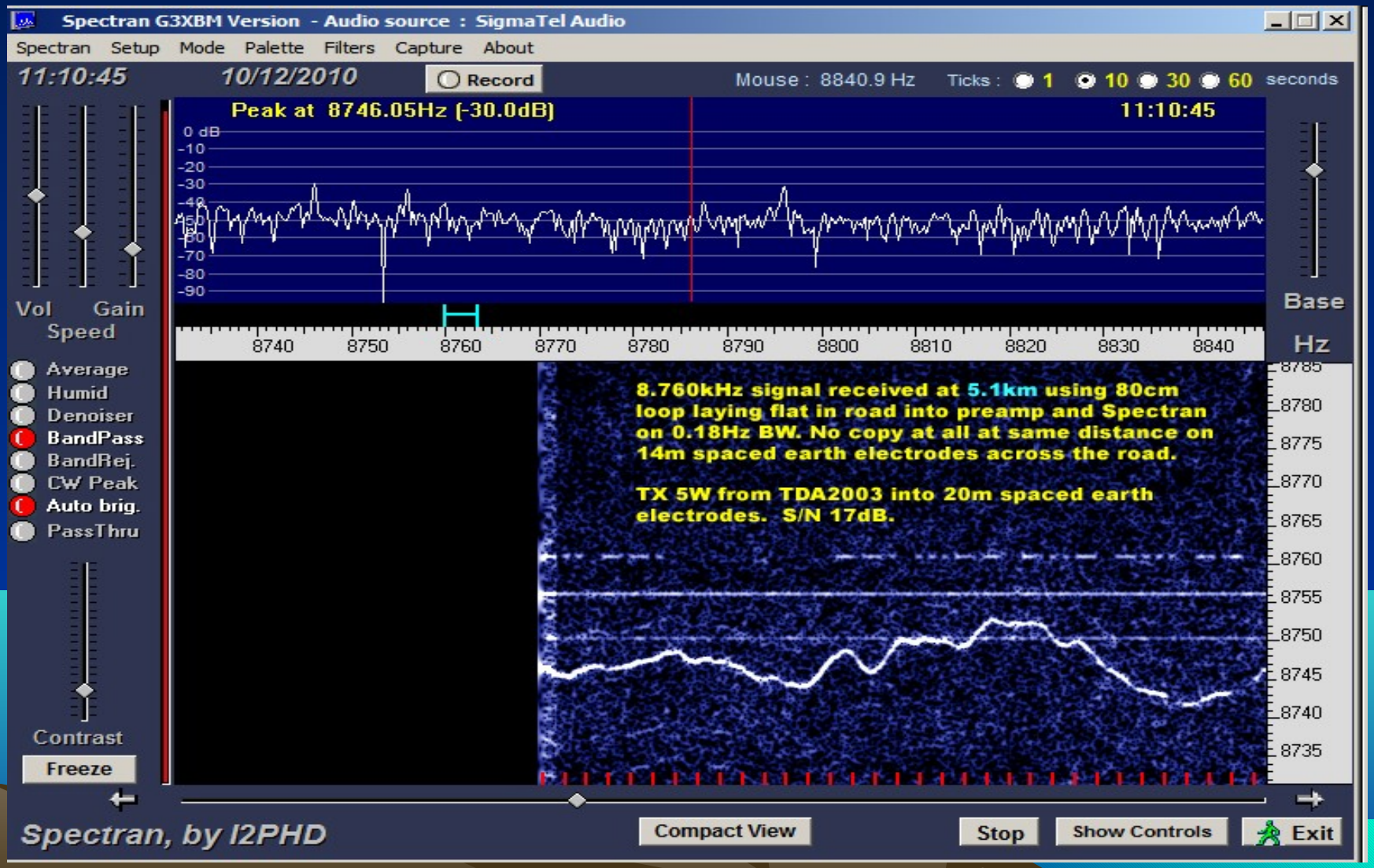
- Set TX running at home in CW or QRSS beacon mode into earth electrode antenna
- Check current in earth-electrode “antenna”
- Go out with /P antenna and PC
- Spectran or Spectrum Lab software used to find signal

2.5km on 0.838kHz

- 0.838kHz ULF signal at 2.5km – strong!

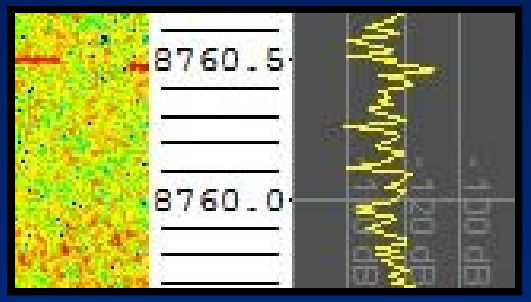


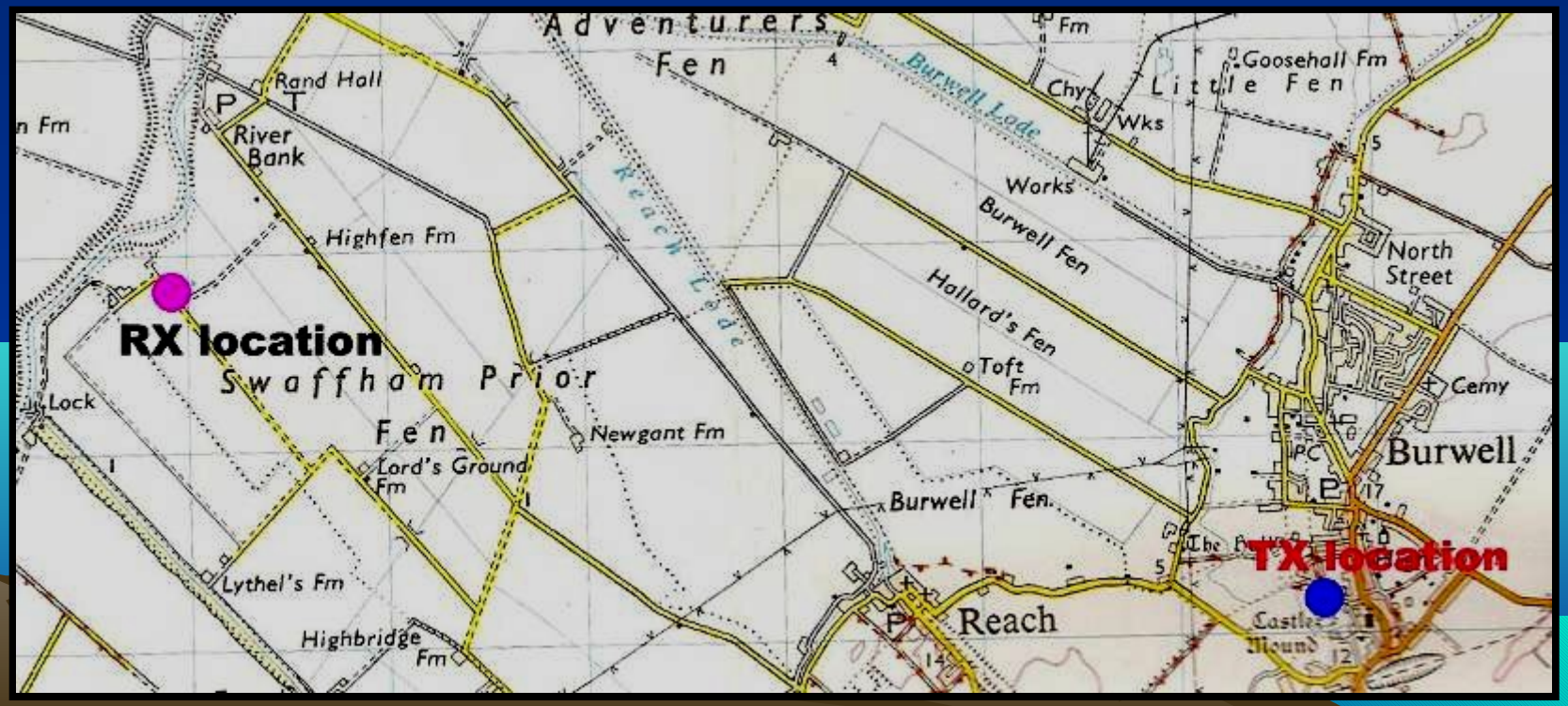
5.1km on 8.76kHz



How far can you get?

- **6km** so far with 5W QRP TX at 8.76kHz in 11mHz DSP filter
- River and sea coast DX tests planned





WSPR on 8.97kHz

- G6ALB received at 3km by WSPR (40W)
- Reception was possible with handheld E-field probe in upstairs shack

Help Needed

- More people looking for earth-mode signals in East Cambs area during tests
- More VLF “grabbers” needed for earth-mode and radiated DX reception
- More local earth-mode VLF TX beacons needed, running more power.

Radiated Sub-9kHz DX

Equipment needed

VLF/ULF reception (same kit as earth mode needed)

- **RX possible without big antennas** (E-field probe or small loop)
- Tuned preamp
- PC with suitable software (Spectrum Lab)
- Very accurate, GPS or similar **LOCKED** frequency setting

VLF/ULF transmission

- Very stable, GPS locked, accurate frequency source
- High power AF amp with keyer + lowest loss matching
- Good insulators for kites and balloons
- Large earth electrode “antenna”, large loop or Marconi vertical

Radiated Sub-9kHz DX

Stations active on
radiated TX near 8.97kHz

- DF6NM
- **DK7FC/P 648km***
- **DJ8WX 645km***
- **G3XIZ 45km***
- **OE5ODL 1046km***
- OE3GHB
- OK2BVG
- PA3CPM

Stations in yellow have been received in Burwell

Typical VLF TX station

- 100 to 300m high kite or Marconi antennas
- 150-600W from PA, 1-70mW radiated
- Ultra-stable GPS locked frequency source
- ATU with HUGE loading coils

- Some people are trying earth electrode and loop TX antennas

DK7FC's 8.97kHz Station

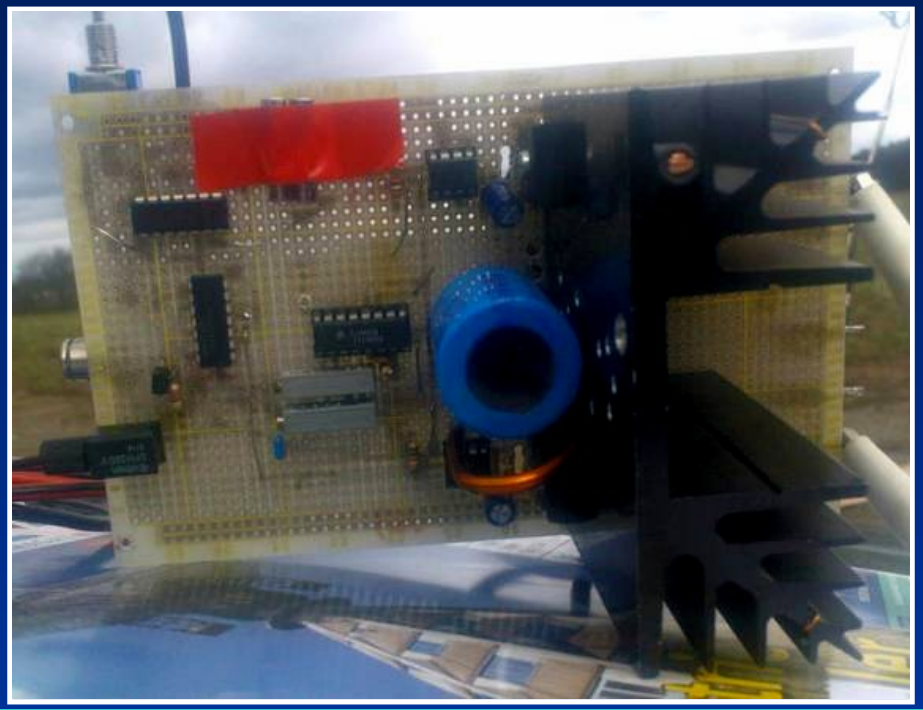
- Loading coil is HUGE
- Kite antenna up to 300m high
- Precise frequency is very important

DK7FC 8.97kHz Loading Coil

- Running 900mA antenna current into the beast
- Kilovolts at top of antenna
- 300m high antenna
- Dangerous!

DK7FC 8.97kHz Transmitter

- 600W PA using power MOSFETs

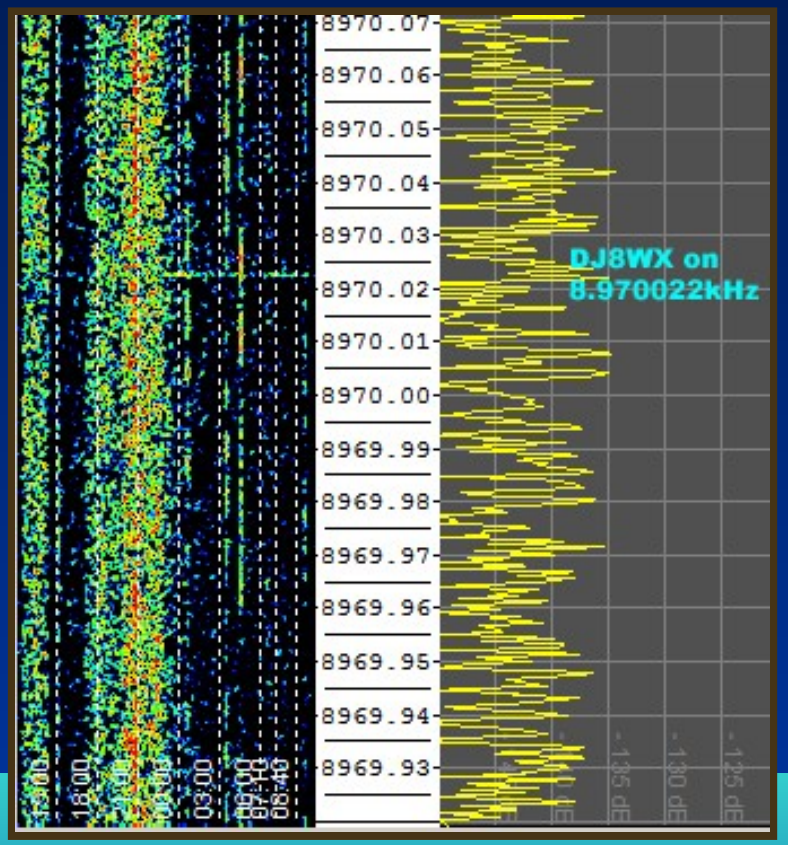


DK7FC's DX reports

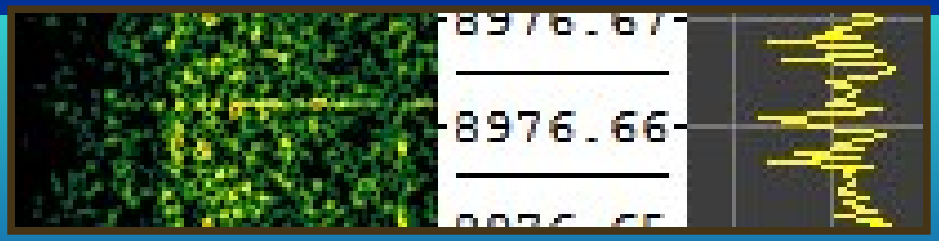
…on 8.97kHz VLF with <100mW ERP

VLF signals seen at G3XBM

- 8.970022 kHz signal received from **DJ8WX** (645km) this spring.
  - Note timescale!



- 8.97666kHz signal from **G3XIZ** (45km) on earth electrode RX antenna



UK Sub-9kHz Activity

- A few NoVs issued for 8.7 to 9.1kHz (100mW EIRP). Only needed for radiated tests.
- G3XIZ has spanned 160km on 8.97kHz
- BIG powers/antennas needed for *radiated* DX
- Radiated DX *should be* possible with large earth electrode “antenna” and QRO (**G3XBM** may try soon)

So finally….

- Simple kit *can* achieve results on VLF RX
- Lots happening on 8.97kHz
  - only simple RX gear is needed.
- More info at
  - **www.g3xbm.co.uk**
  - **https://sites.google.com/site/sub9khz/**

73s and any more questions?