

A Contemporary LF/MF Ham Station

Peter Hall (VK6HP / VK6MJM)

p.hall@curtin.edu.au

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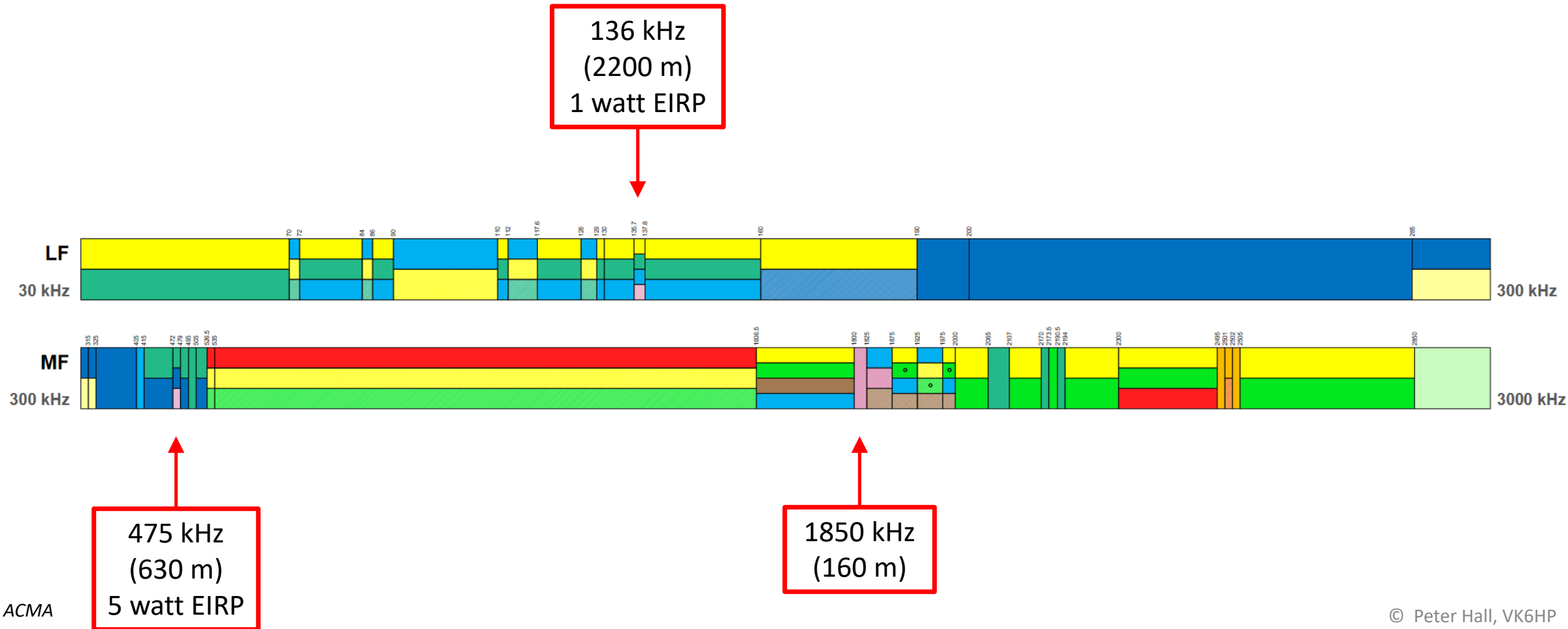
*Pic: Audrey Bell,
VK6FAUD*

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Presentation outline

- My motivation for building an LF/MF station
- Introduction to VK6MJM
 - LF emphasis for brevity
- Station technology overview
- Some first results
- Future directions
 - Including science

LF and MF amateur bands



Motivation: why LF/MF, why remote?

- Interesting **technology**, e.g.
 - Antennas: only just beyond lumped-element circuits
 - Signalling: experiments with information transfer at very low SNR
- LF/MF **propagation** and **radio science**
 - LF propagation often characterized by VLF (waveguide) or MF/HF (ray) models
 - Lots of history, but also new tools for improved probing and modelling
- VK6 fell into a void in world LF transmitting and receiving coverage
 - Significant omission for propagation studies
 - No LF broadcasting in AU; VLF military transmitter at North West Cape (NWC, 19.8 kHz)
- Big (transmit) antennas → go rural/remote
 - Physically big antennas, but often < 0.01 wavelength electrically
 - Remote stations allow more hams to operate efficient LF transmit antennas and low-RFI receivers...but are by no means the only approach
 - VK6MJM antenna is comparable in size to many ham towers / wires

Amateur LF/MF in 2025

- Still experimenters' ham bands, requiring more than a credit card** to succeed
- Probing anomalous propagation (aka “very rare DX”) beyond previous limits
 - e.g. JT-mode signalling such as FST4(W) beacon and QSO modes
- More commercial T/R equipment now available
 - e.g. Kenwood, Flex, Elecraft, ANAN, Hermes Lite, ... transceivers produce ~ 0 dBm drive, with good receivers
- Good receive antennas to buy or construct
 - Active and passive loops (large and small), active arrays, new ways of building classic designs (e.g. DSP),
- Efficient power amplifiers (Class D/E switching) “easy” to homebrew
 - Antenna current is cheap – fewer efficiency imperatives
- Better and easier metrology readily available
 - Better test equipment for home building, antenna tuning, transmission monitoring,
- Good software tools
 - Cheap or free computational electromagnetics (EZNEC etc.)
 - Remote Desktop for station operation (AnyDesk, TeamViewer,OtherStuffForCommonFolk)
 - Custom station software not essential if hardware is selected/built appropriately

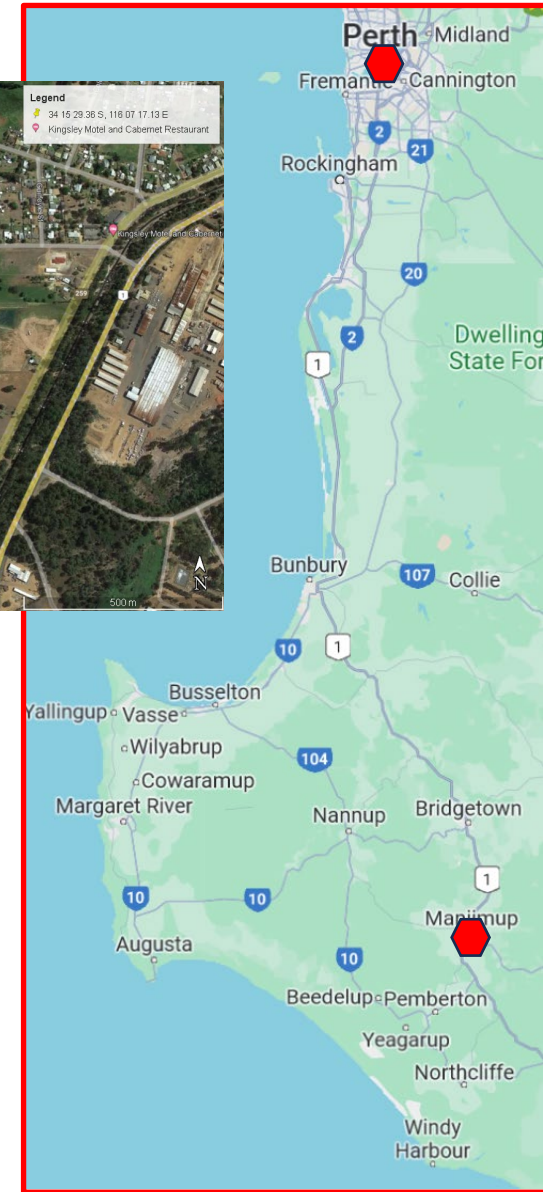
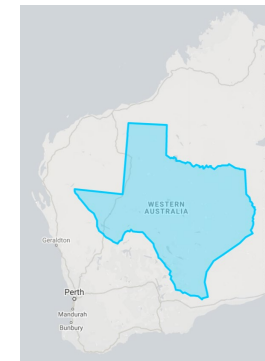
VK6MJM: a re-born NDB

- 22.5 m (74') umbrella-loaded live-mast antenna
 - Electrically very short:
 - 13° @ 475 kHz \rightarrow 0.8Ω radiation resistance (R_r)
 - 3.7° @ 136 kHz $\rightarrow R_r = 0.07 \Omega$
- Self-resonant ($\lambda/4$) frequency of antenna = 1795 kHz
 - Essentially 160 m amateur band!
- Ground radial field of unknown extent – originally 30 x 22.5 m radials ?
- Good quality steel shack – about 3.5 x 3.5 m (10' x 10')
 - Wall-mounted air-conditioner, workbench, 240 V mains power
- Antenna coupler (“tuner”) near mast
 - New, homebrew IoT-controller coupler commissioned last week
- T/R operation via internet and remote desktop

VK6MJM location



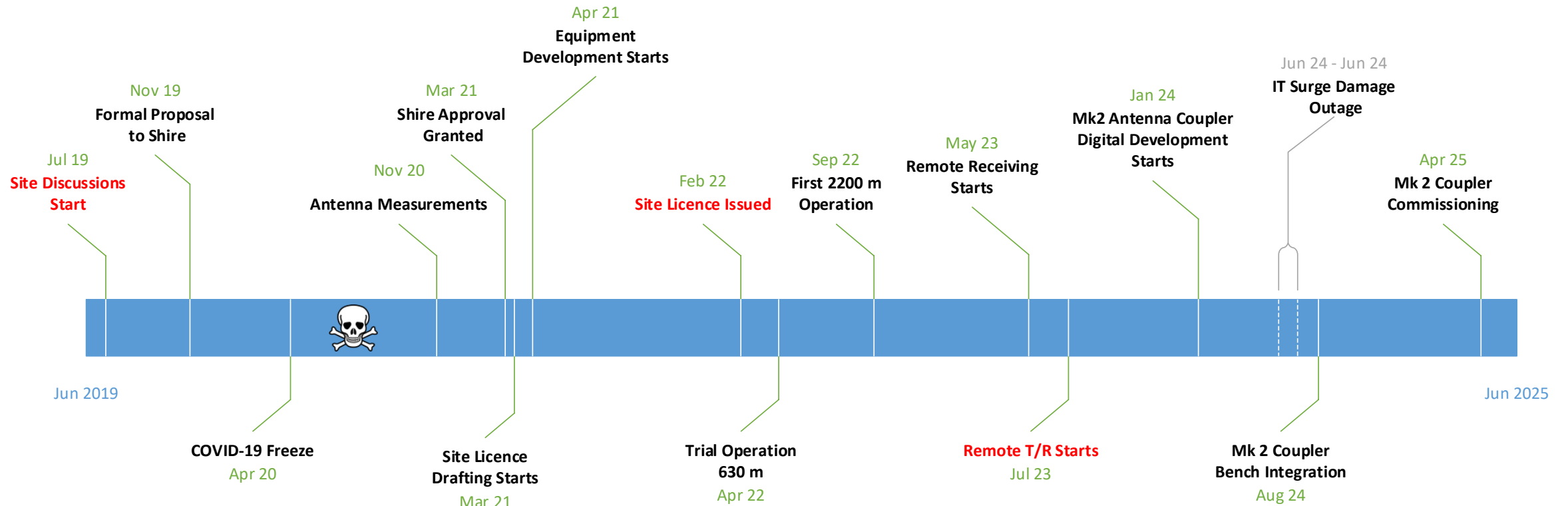
VK6MJM



Manjimup: About 3.5 hours drive from Perth

WA ~ 4 x Texas in area ☺

6 years of VK6MJM

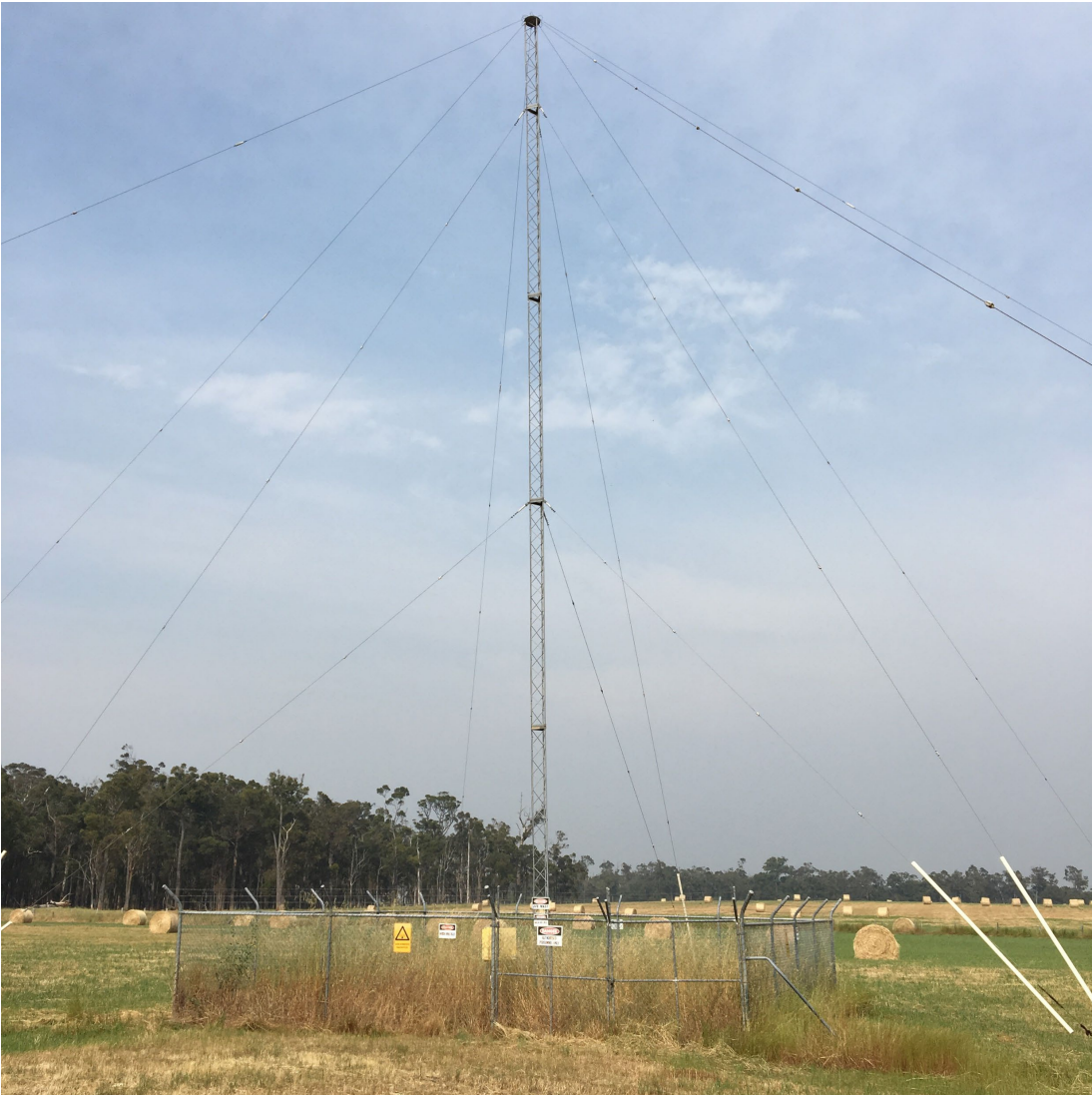


"Shire" ≈ rural county

Some initial VK6MJM design decisions

- Both transmit (legal limit) and receive operation at LF/MF
 - Mains power, site RFI minimization, use of transceiver, ...
- Year-round operation
 - Shack air-conditioning, efficient thermal control, diligent site maintenance, ...
- Capable of long-duration digital, as well as other, modes
 - Local PC for high-fidelity signalling, transceiver TCXO, ...
- Internet-based remote control
 - Remote desktop for easy and extensible operation, autonomous local safety systems, ...
- Emphasis on radio technology development, but system choices consistent with (eventual) integrated software solution
 - Commercial hardware with control/monitor apps and drivers, W11 operating system
- Relatively fast-track development
 - Re-invent as few wheels as possible
 - Reliable “installable prototype” hardware, with functional documentation

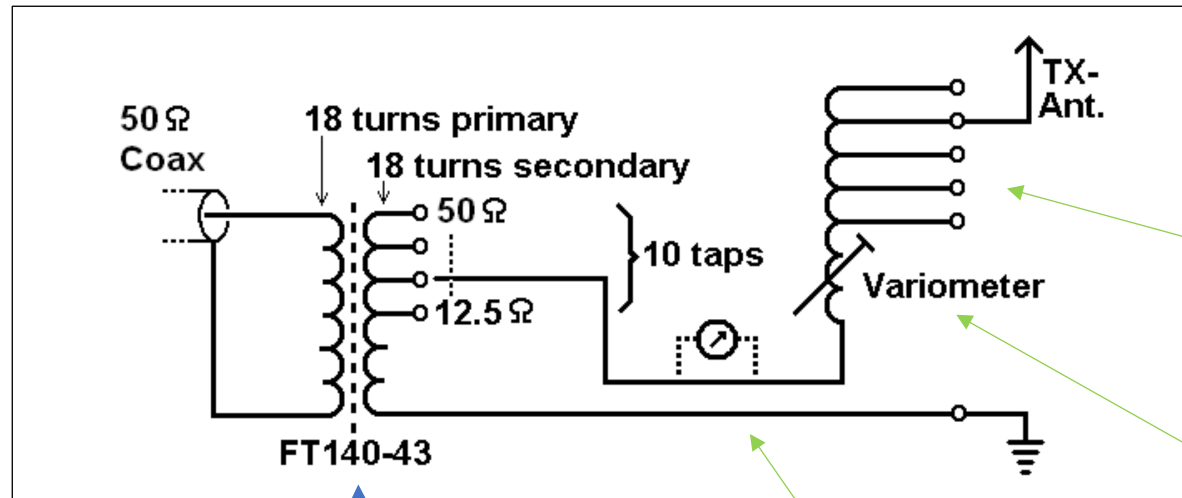
Antenna views



New coupler
(April 2025)



LF/MF antenna coupler – typical form



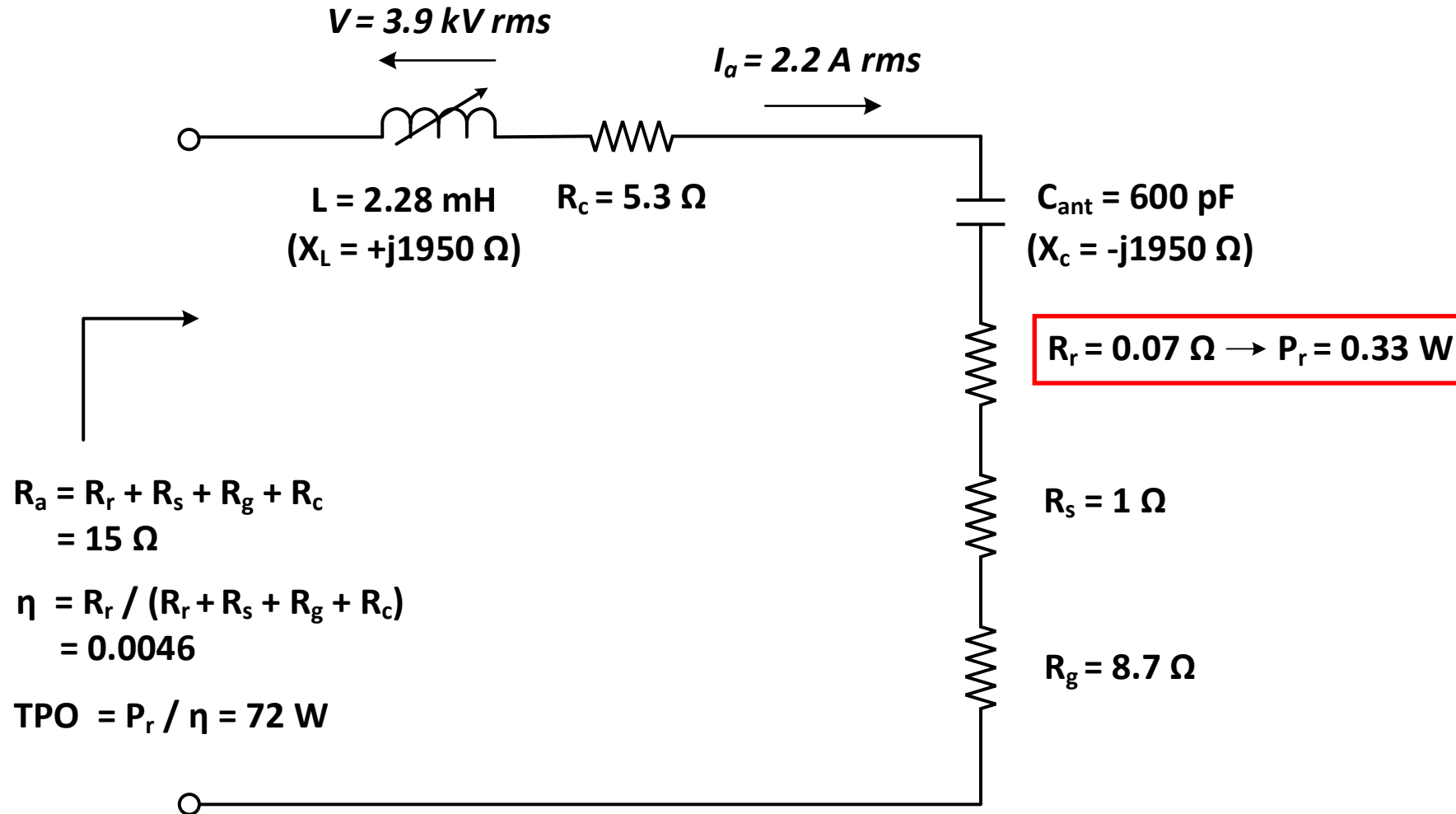
Tapped impedance matching transformer: resonant resistance → 50 ohm feeder

RF ammeter

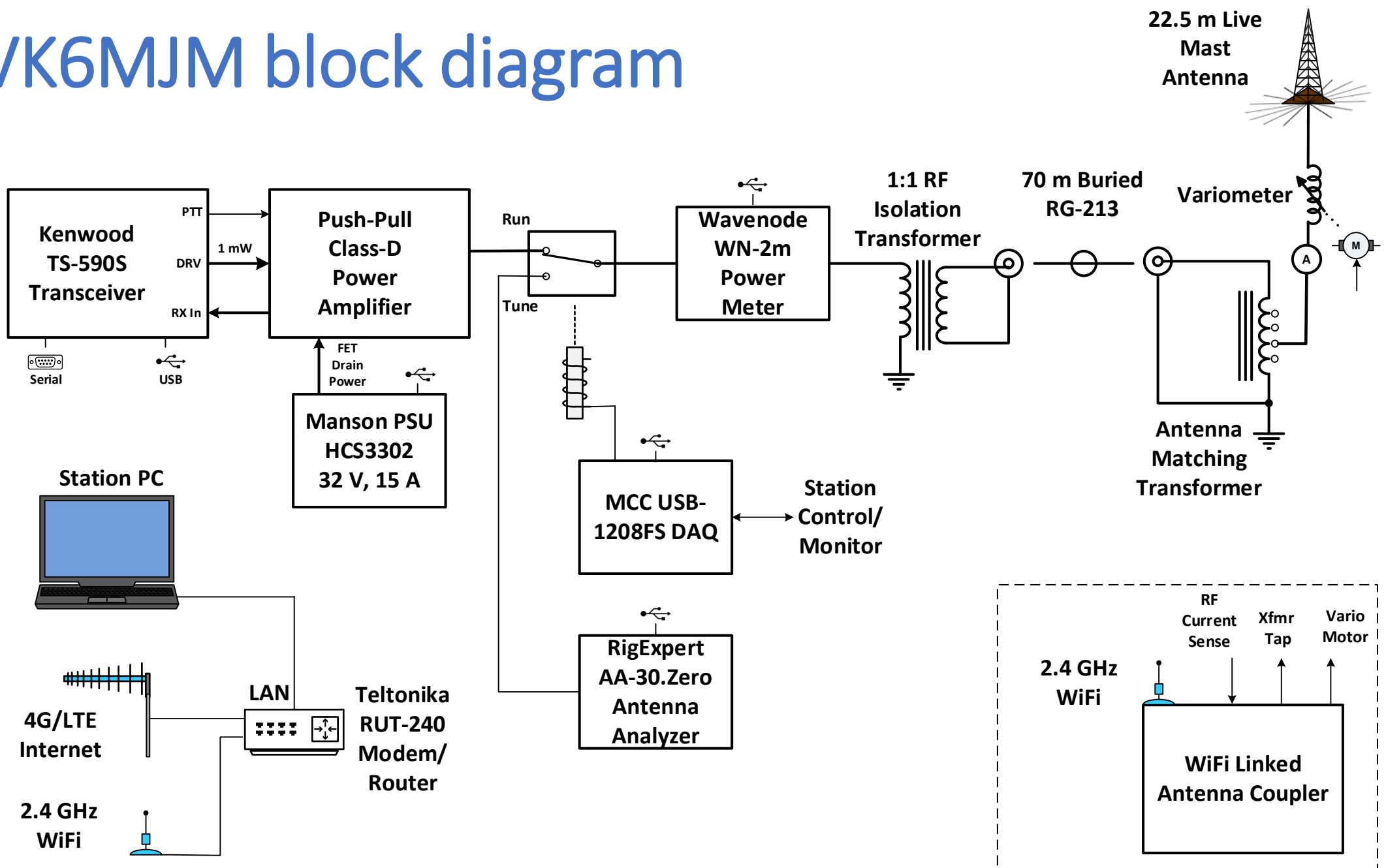
Large “loading” coil to resonate with short antenna’s capacitance (2.3 mH at 136 kHz)

Variable inductance for fine tuning resonant frequency

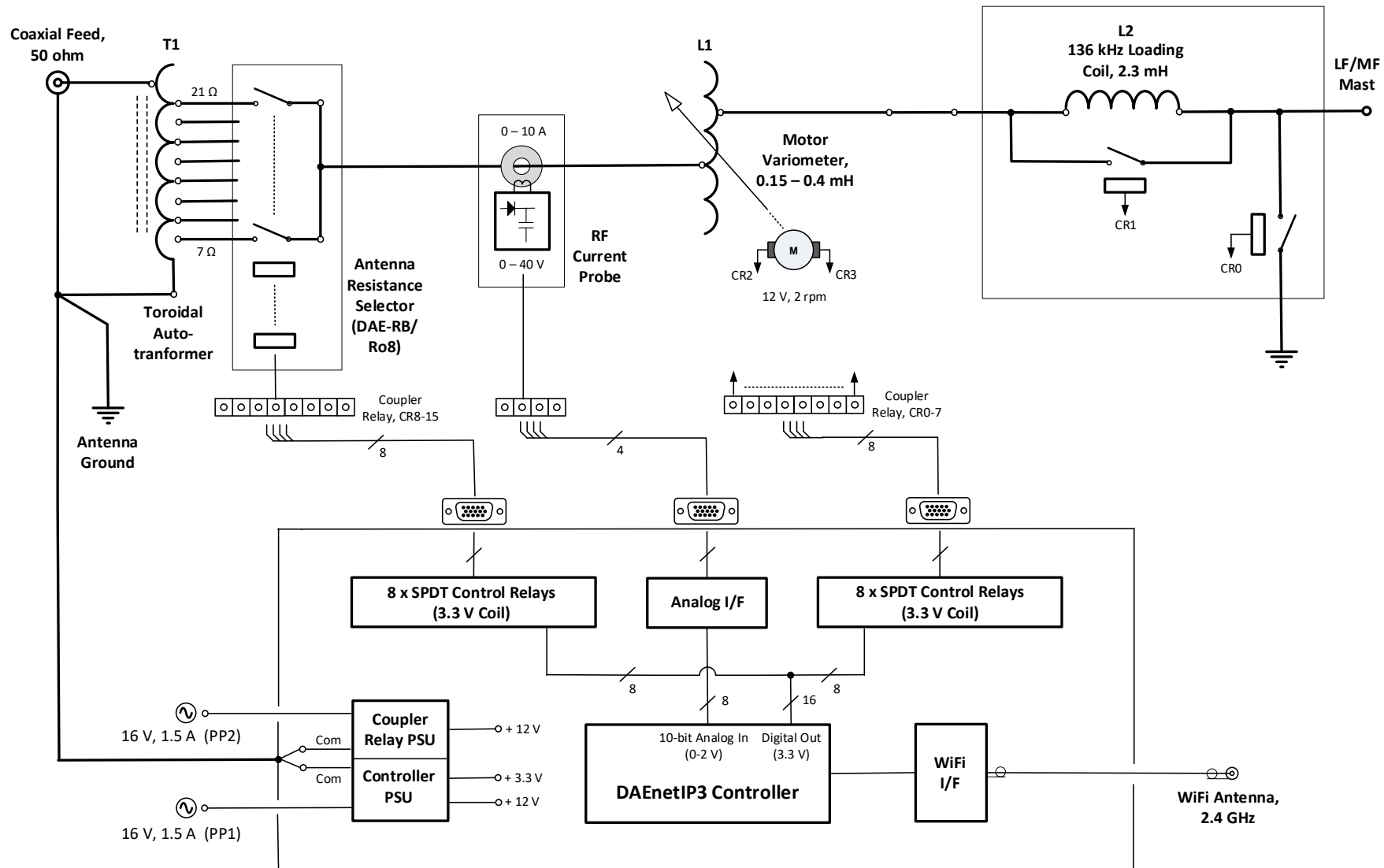
VK6MJM at 136 kHz, 1 W EIRP



VK6MJM block diagram



New Remote (IoT) Antenna Coupler



Highlights:

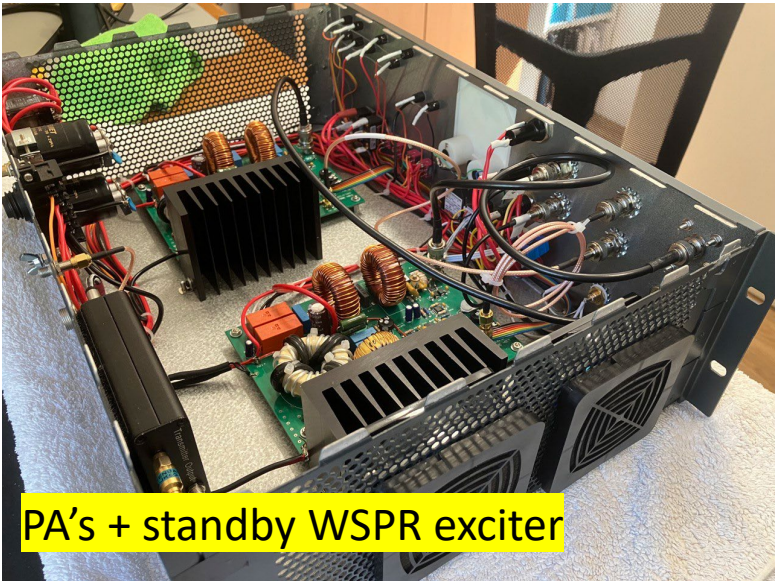
1. Galvanically isolated coupler control
2. Flexible and extensible
3. Both R and X tuning
4. Good EMC from both culprit/victim directions

Hardware snapshots

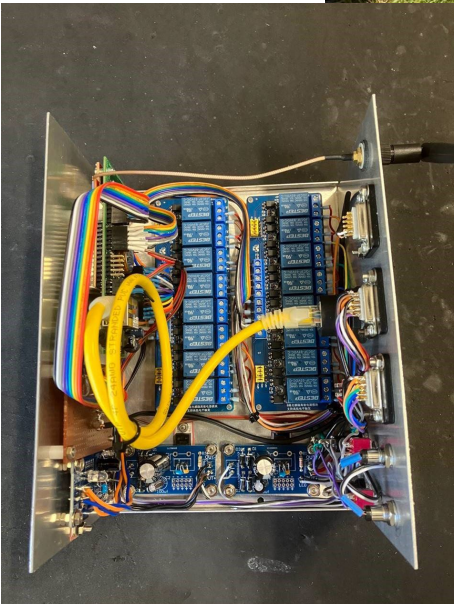


Rack (with TS-590S)

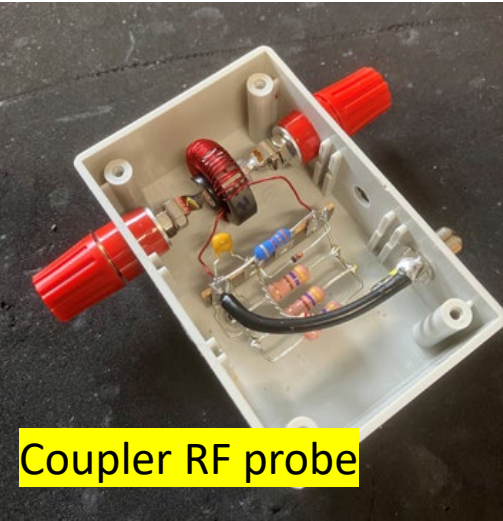
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PA's + standby WSPR exciter



2.6 mH, $Q = 370$
LF loading coil

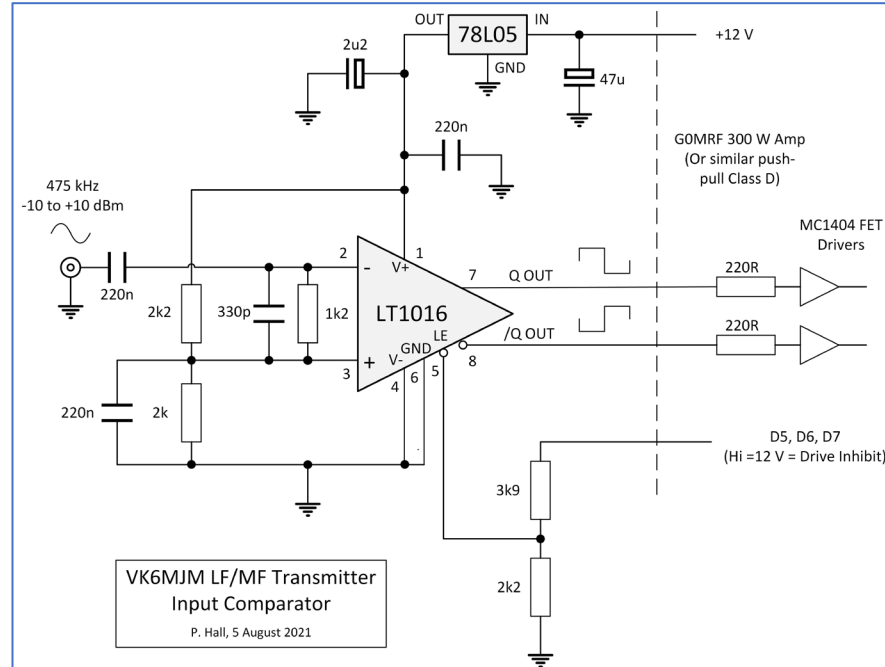


Coupler RF probe

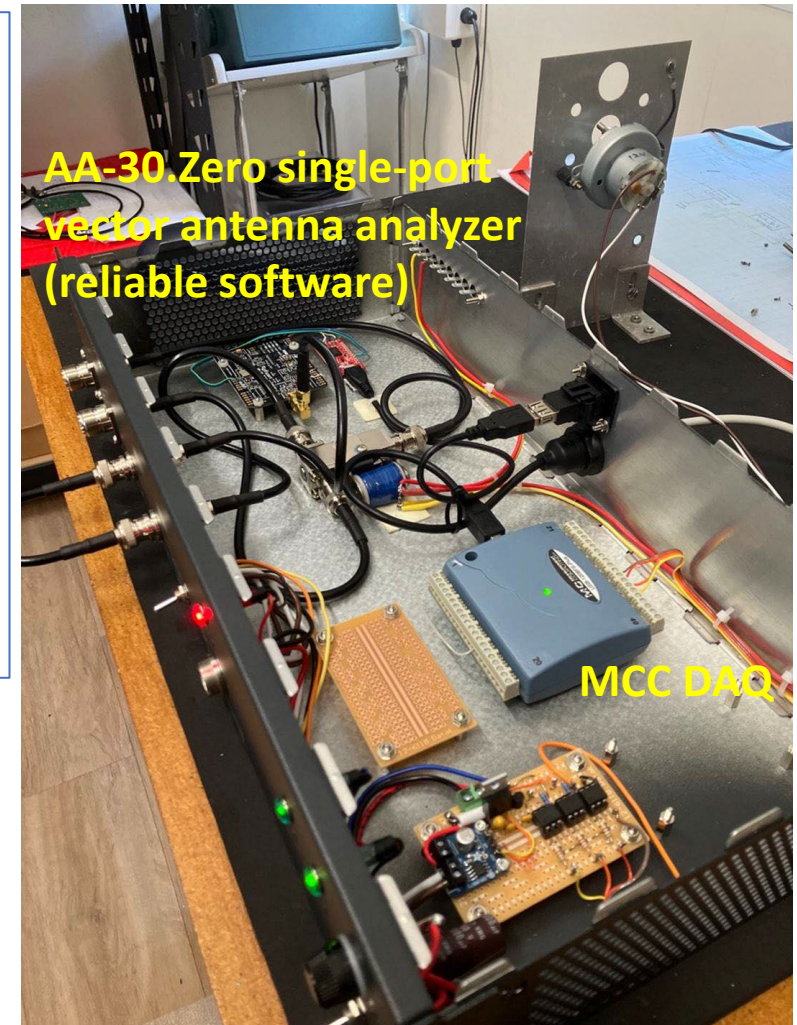


WiFi coupler controller

More hardware

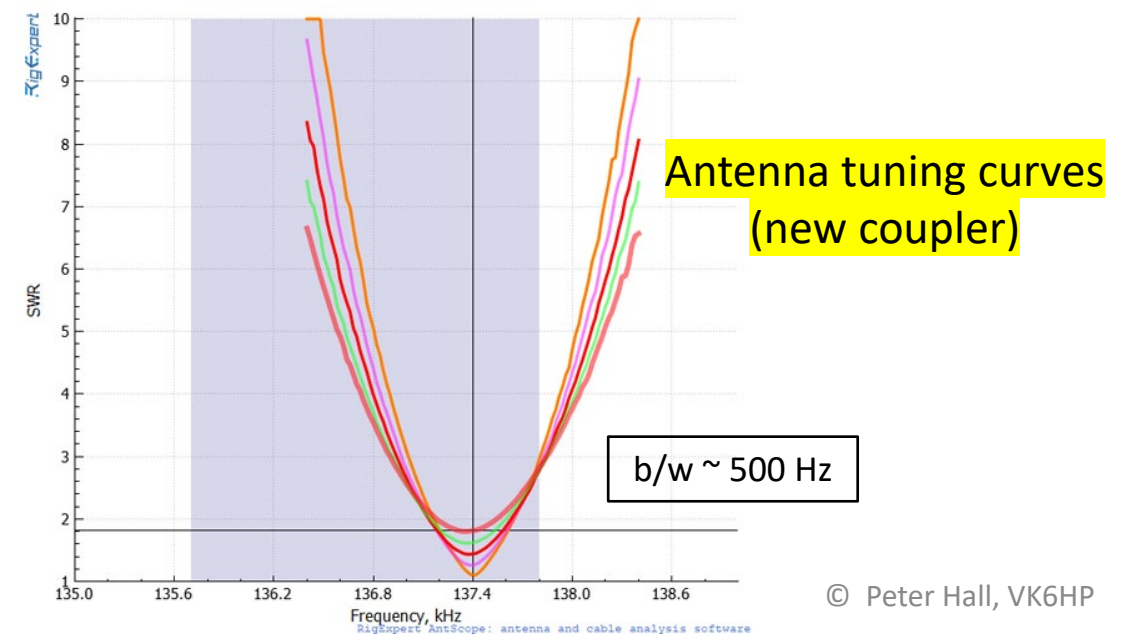
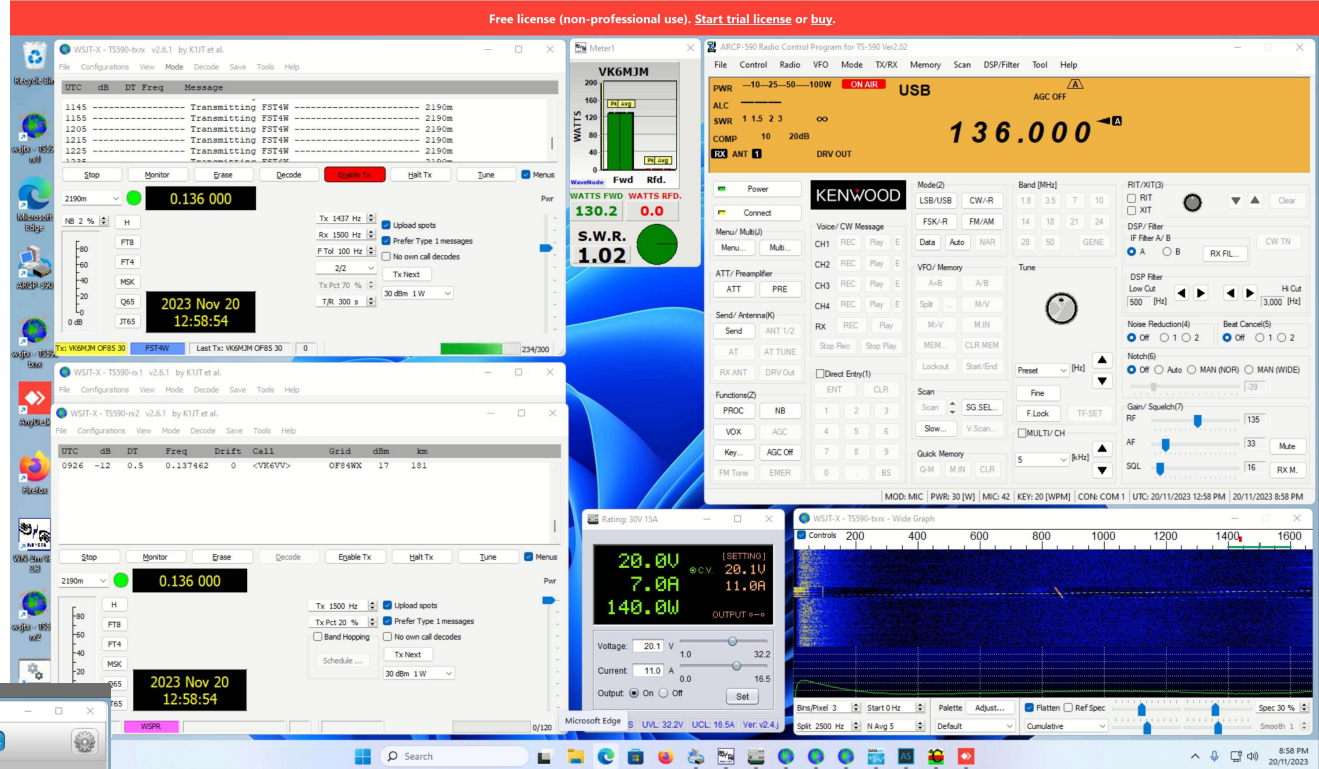


Fast, low-jitter (phase noise) comparator (direct signal frequency input)



“Tune”

“Run”



© Peter Hall, VK6HP

Results to March, 2025

- WSPR 2, FST4W-300, FST4W-900 transmissions
 - New coupler removes previous key-down time limit
- Antenna currents around modelled values
- 475 kHz field strength @ 1 km ~ 80% of expected value (1 dB)
- Oceania → North America 136 kHz one-way digital record
 - Repeated many times with KM5SW using FST4W-300; extended to 16,823 km with SWLEM3
 - Hard-won spot with KL7L (Wasilla, AK)
- Very new FST4W-900 spots by KPH, W1CK, K6VZK
- Best 475 kHz (WSPR) spot by KL7KY (Talkeetna, AK)
- DL7NN, R2BM, R7LP, UA4AAV, JA1NQI, JA1RWI, JH1OFX, G3SDG, ...
received on 136 kHz – frequent repeats in most cases
- Formed overview of seasonal propagation trends
- Encouraged other VK6 amateurs to try LF/MF

Selected STEM topics

- Propagation studies
 - LF/MF skywave: when, where and how? Correlation with key physical indicators?
 - Trans-equatorial vs mid-latitude path behaviour
 - Importance of path spatial/time variation, and choice of signalling mode
 - Simultaneous multi-mode studies (need a linear PA)
 - Data visualization (WSPR Live)
- Non-linear power amplifier design
 - Improved Class D or E designs
 - Better characterization of stray reactances (esp. magnetic components)
 - Better understanding of load matching on C/N ratio
- Communications systems operating near the theoretical limit
 - E_b/N_0 characterizations
 - How do JT-mode FEC systems stack up in practice?
 - Especially when “robust” error rates are set in decoding software


Future VK6MJM directions

- Directional receive antenna(s)
 - Beverage, loop,
- More integrated software, better documentation
 - Easier, safer operation by more people
- More bands and modes
 - Incl. 160 m + HF phone
- More STEM education
 - Uni projects, ham education, high school science, ...
- More serious (and systematic) propagation studies
- LF/MF linear amplifier: simultaneous signalling modes
 - e.g multiple JT modes for path studies
- Other non-commercial uses of site
 - e.g. Kiwi SDR

Closing thoughts

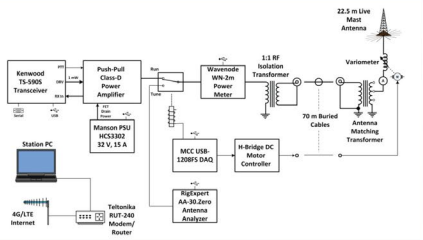

- VK6MJM is an unusual ham station, with a projected 5-10 year lifetime
- There is considerable scope for fun, engineering, science and education
 - Only minimally responsible to external stakeholders!
- VK6 location fills a void in the distribution of Global LF ham stations
- VK6MJM is particularly competitive on 136 kHz
 - RFI-quiet location; antenna efficiency allows EIRP limit to be reached easily
- New-generation LF/MF is a sandpit for electronics, antenna, propagation, edge-of-envelope communications, and IT/networking projects
 - And probably much else

Further VK6MJM reading



A Forum for
Communications Experimenters

July / August 2024
Issue No. 345 | www.arrl.org



Peter Hall, VK6HP, repurposes a decommissioned LF directional beacon into a 2200- and 630-meter remote amateur station.

Radio Engineering

A site devoted to the radio engineering and technology activities of Emeritus Professor Peter Hall and friends.

Still under construction, so be patient!

Amateur Radio (VK6HP)

Amateur Radio (VK6MJM)

Other Activities

Publications and Notes

About Peter



Moonrise at VK6MJM, April 2023 (Credit: Peter Hall)

One watt QRP

Out of NDB tower

Hello to the world!

HighQ poetry by Dave, VK6KV

Starter LF references (selected)

1. Antennas for 136 kHz, Rik Strobbe (ON7YD), <https://www.strobbe.eu/on7yd/136ant/>
2. Antennas by N6LF, Rudy Severns (N6LF), <https://www.antennasbyn6lf.com/>
3. G0MRF Projects, David Bowman (G0MRF), <https://g0mrf.com/>
4. NDB antennas, John R Pinks, https://nautelnav.com/content/user_files/2023/05/NDB-ANTENNAS-Pinks-Jan-2012.pdf
5. Radio Antenna Engineering, Edmund A Laport, <https://www.e-booksdirectory.com/details.php?ebook=1156> (*an old, but good, reference for LF antennas*)
6. Understanding LF Propagation, Alan Melia (G3YNK), in [https://rsgb.org/main/files/2012/10/Understanding LF and HF propagation.pdf](https://rsgb.org/main/files/2012/10/Understanding_LF_and_HF_propagation.pdf)