Proceeding number 15-59

Before the Federal Communications Commission Washington, D.C. 20554

Amendment of Parts 1, 2, 15, 25, 27, 74, 78, 80, 87, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radio communication Conference (Geneva, 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates (ET docket 12-338)

Amendment of Parts 2, 15, 80, 90, 97, and 101 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radio communication Conference (Geneva, 2012)(WRC-12), Other Allocation Issues, and Related Rule Updates (ET Docket 15-99)

Petition for Rulemaking of James E. Whedbee to Amend Parts 2 and 97 of the Commission's Rules to Create a Low Frequency Allocation for the Amateur Radio Service Petition for Rulemaking of ARRL to Amend Parts 2 and 97 of the Commission's Rules to Create a New Medium-Frequency Allocation for the Amateur Radio Service

To the commission:

Comment from Laurence J Howell IEng MIET MIEEE FRGS KL7L, and Part 5 license WD2XDW (from 2003), WE2XPQ (current) and others part 5 licenses

Im an engineer by profession having worked some 40 years in both military and commercial telecommunications and automation/control systems markets worldwide.- I have held my UK amateur radio call sign since 1974. Since 1978 I've held long radio telephony/telephony qualifications for coast station and ships and have operated in this MF spectrum over the past years

Part 5 history and locations (questions posed in section 169)

In 2003 I was granted WD2XDW West Anchorage Alaska to perform circa 137 kHz experimentation on antenna performance with limited space, propagation in sub-Arctic and transpolar communications at high geomagnetic latitudes, and investigate digital and analogue communications modes.

After a few years work moved me to Bartlesville Oklahoma where the station up again, and again 2 years later to the other side of town before moving to Asia and retiring XDW

In 2010 WE2XPQ was licensed in Wasilla Palmer Alaska, about 55Kms North of Anchorage - the station initially operated on 137kHz at some 3W ERP, and 505-510, then circa 460-480 kHz at calculated ERPs to >20W

Support for FCC position and methodology in sharing described in FCC per FCC15-50

I actively support the adoption of both 137 kHz (2000m band) and circa 475 kHz (472-479 kHz) potential amateur allocations and sharing with Part 15 compliant power utilities. I can support both WRC07/12 EIRP limits, an antennae height limit of 200ft (however see comments later) and could accept a 1Km transmit distance limit between an amateur radio station if the PLCC is co-channel, however, see comments later. I believe that automatic selection of clear channel for data signals (within a recognized “band plan”) within the allocation is acceptable -

I recognize the importance of PLCC (PLC) systems operating under part 15 and seek accommodation to *sharing* the two small slivers of bandwidth being discussed and not causing risk of an unwanted conditions on the transmission system.

This can be done. This should be done.

Interference statement (Section 166)

The station has been transmitting for **many thousands of hours** on both circa 475 kHz and 137 KHz (2000m band) from multiple location and US states using digital and analogue transmission and reception methodologies with transmitter powers and ERP/EIRP levels far exceeding WRC-07/12 standards without any interference complaints

At some stages the 137 KHz transmitter was on continuously for over a 1 month period for ground and sky wave profiling during low level solar flux and stable geomagnetic periods

PLC reception (section 171)

PLC signals from overhead lines were heard at levels to 50uV on approx. 170 kHz whilst surveying and only running parallel to main power lines near location 3. They were just audible on the Omni directional receive system at the main station at about 1 mile.

Subsequent field surveys looking at PLC signals and relative field strengths by distance in Anchorage on their Hv lines/sub stations are discussed further.

WD2XDW Alaska (location 1)

My location in Western Anchorage Alaska was ideal for this kind of work given sparse human population but large bear population and relatively clear environment..

Overhead power lines within 200m to 35Kv and underground 12/35Kv cables running parallel to the antennae site only 50m away did cause some noise issues on receive but we had no interference complaints with thousands of hours of transmissions up to 5W ERP from a 110ft T Marconi and extensive earth radial system. The radiation pattern was nearly omnidirectional as expected

The station was located less than 1 mile from an FCC field office and the same distance from the Ted Stevens International airport boundary and less than 2 miles from overhead 115/138/230Kv or more power line transmission system and power generation plant. The antennae pattern by survey was typically Omni directional on ground wave but this fell off very fast when entering or crossing the nearby mountains. Ground conductivity was poor.

WD2XDW Oklahoma (location 2)

On moving to Bartlesville I was unable to put up a tower as it was a leased property and resorted to try out various natural supports available

Driven by dedicated and ground breaking work by the late Bill Ashlock work on small circumference high current loop, and relatively lower voltage antennas which tend to have less loss that higher impedance Verticals in Boreal locations,. The antenna installed was multiple paralleled 6/8 gauge TFFN cables in a 500ft circumference loop over a couple of Cotton woods.

At 137 KHz 1.6Kw was developed from an old Class D Decca transmitter and produced around 3W ERP in the main lobe, with approaching 60A Loop current being carried in the multiple conductors.

This was one of the first high powered uses of very small (wavelength wise) transmit loop at these frequencies, and although the efficiency is low, by the reception reports received it was still quite effective –

Certainly it won't produce more field strength from a 110ft Marconi installed in a cleared area with an expansive ground system but it is an alternative for a smaller garden and is typically less lossy in wooded areas.

Groundwave was excellent here given the conductivity and CW audible levels during daytime were more than 600 miles at this power level (using a small e-probe and receiver in a car), and on good days sky wave made it to New Zealand using digital reception and slow data techniques.

I was about 3.8 Miles from overhead transmission and main sub stations for the City

A polar diagram of the radiation pattern of this loop array conducted is Attachment 1. – This will be referenced later

WD2XDW Oklahoma (location 3)

The last house had a postage stamp back garden and surrounded by similar postage stamps – the only effective antennae was a top loaded vertical, helically wound, and at 1.5Kw struggled to reach even close to 1W ERP by measurement at 137 kHz. I only had a short time there before having to leave.

WE2XPQ Wasilla Palmer Alaska (location 4)

XPQ is located on an acre of heavily forested land next to a lake. XPQ has limited antenna height allowance as it's at the end of an active runway – so given our past experiences of how nested Marconi's can be very lossy in forested areas at lower frequencies a to 500-600 ft. thick conductor loop up with some 70ft vertical section at one end and 50ft at the other, the vertical height being important.

This is also interchangeable with a offset Marconi and extensive earth mat and radial system, however it's again in the middle of a boreal forest and losses are high but manageable. At 137 kHz for the same power and in the main lobe the loop performed much better (8-10dB at 100Kms) over the Marconi

Groundwave is much poorer here in Alaska with values of 2-4 milliSiemens per meter, and ionospheric losses can be very high at times given Geomag/geolatitude, with huge sky wave variation just over a few hundred Kms -

A polar diagram of the loop antenna operating at 506 kHz is **Attachment 2.**

Ground wave on 475kHz is subject to high losses in mountainous terrain (typically close in 1 x 1000m mountain is 6dB of loss) and poor earth conductivity – sample field strength map is shown as **Attachment 3**

Transmitter power at 137 KHz is up to 1.6Kw output for a major lobe ERP of 2.5W on the loop and up to 500W on circa 475 kHz with an estimated ERP on the Marconi of 17W at 200W input for 2A aerial current

Can I see Russia from my back yard?

Per section 161 of FCC 15-50 we would be greater than 800km from the Russian border and therefore if granted as a amateur band wouldn't be constrained to the 1W EIRP limit

Comments on 15-50 (Section 159)

I agree with the EIRP limits for both 2200m (137 kHz) as 1W, but experimentally given the number of active stations within the USA, Canada and elsewhere this could easily have been increased to 3W ERP (ERP) without issue – weve just not experienced any complaints from any sources over many years of experimentation just to prove that point.

For 472-479 kHz I again agree with WRC-12 limits of 5W EIRP, again nothing in all our likeminded experimenters work over the past 12 years or so gives me any concerns

Coexisting with Power utilities and PLC coupling – (Section 159 and others)

I see some general movement away from PLCC systems to IP low latency transport "Smart grid" which are resilient enough and fast acting to protect the lines – however Im sure RF carrier PLCC systems will be around for a while.

PLCCs

One of the main issues we have is the idea of coupling from a transmitter and antennae into an active PLCC overhead power line system

By design Utilities design their Power line Carrier communications (PLCCs) to have a very high system integrity and thus availability to perform a multitude of operating functions.

Design thoughts

When designing a new system they have to mitigate sometimes very high Corona noise at times, single or multiple phase to ground faults shunting the PLCC signal, additional RF ice losses, impulsive noise from lightning, pass thru losses if a multiple section transmission system is used, and out of band unwanted broadcast and licensed non directional beacons.

Studies would be done finding the best frequency, working out the transmission systems characteristic impedance, and per any typical radio path calculation, total losses both in normal mode (fair weather), poor weather condition or fault modes, and avoidance of any high powered co-channel navigation beacon, or say amateur band.

The aim being to have a sufficient signal to noise to meet all the above normal and fault condition beyond line attenuation additional losses in the filters (band pass, band stop and high pass), coupling capacitance, attenuators to flatten mismatch, drain coils and surge protection losses and hybrids

From openly available information higher system availabilities occur if such a carrier system is hybrided into multiple phases – loss of one phase to ground would then only reduce the signal by 6-8dB

Typically longer transmission lines use higher power and lower frequencies and shorter transmission systems higher frequencies – examples seen are around 90kHz for one for a 500Kv and 250Kms line and 240kHz for our local version here in Alaska.

I don't have any records available of many PLCCs using the sliver 137kHz band and circa 475kHz region, but looking at the freely available US transmission maps I don't think there are many, and the number of active 137/475kHz within a specified number of meters is going to be really small, real small, and easily coordinated.

PLCC Output power models vary from just a few Watts to 1000W PEP or more – receive sensitivities typically may need a minimum of -40dBm, and I've seen some quoted as "5mV up to 500mV" of received RF voltage to have adequate signal to noise and thus attenuators may be used.

The aim is the same – to get a signal to noise ratio for what is effectively a terminated transmission line at around 40dB, typically 30dB s/n and worse case on "an icy night with a lightning and wind storm, accompanied with volcanic dust Corona and a phase fault" (sic)

As in any RF transmission system there is a series of components to match the PLCC transmitter to the transmission conductor or conductors. Typical transmission line impedance could be 300-450 ohms for a single conductor and 250-350 ohms for multiple cables therefore various inductance and capacitors are added to match the output impedance of the transmitter and at the receiving end or ends. –

The utilities will want maximum power transfer and highest return loss of their system – they don't want the transmission system to radiate or be radiated by, and from selective testing they appear to be doing just that and acts a reasonable well matched and terminated transmission line.

As per normally well terminated transmission lines they tend to rejecting unwanted coupling even if a long line suffers a conductor position change enroute to help matching at 60Hz

A simple example here in Anchorage is a 230Kv new transmission grid line that runs parallel to a tower carrying multiple 50Kw signals in the low 500kHz ranges, measured field strength voltages impinging on this transmission line and from a nearby 1Kw Non directional beacon are in the order of 10's of Volts. No issues obviously**.**

Power/height limitation (Section 168)

Im not in favor of any specific power limit – plainly, given the various types of antennas and where they are placed the results would be very poor – it would certainly be the case here in Boreal Alaska - keep with ERP/EIRP per the rest of the world. It's proven to work.

Height and "fixed" limitation – I don't have an issue with limiting the height to 200ft – but there have been instances where temporary access to broadcast or utility/military owned towers has been gained and experimentation at 137kHz has taken place (based on the part 5 license having a radial distance allowance) – I would hate to limit that type of opportunity both in height and temporary locations as the science produced can be very valuable. I'd still like some form of timely permission process for temporary operation in both bands.

Power line noise (Section 171)

Both transmission and distribution grids are highly noise variable – I tend to get more noise from 7.5/12/5/34Kv than my main transmission system. The new Alaska Rail belt 230Kv is exceptionally quiet and well designed in my view – I probably would avoid putting a 137 kHz station within 500m of a main transmission system due to unwanted non fault corona noise, and a technical requirement to see sky/ionospheric noise - but I've set up 137Khz/475kHz successful receive stations within 50m and 150m in Chinese industrial areas (that was noisy), 1Km in Scotland, 75m Sabah, 200m Ghana, 1Km Namibia, 1.1Km Mongolia and at 50m in Mexico (no issues).

New power line (Section 172)

If a new transmission line is to be built avoid 137 kHz and 475 kHz regions– the same as you would do in avoiding a very local navigation beacon. The optimum frequency chosen maybe a function of line length planned but, but even then the choice of a 4 KHz "channel" there is a lot of latitude.

I technically don't see the necessity at all of why these slivers would be chosen over other adjacent frequencies. Typically the frequency can be moved pretty quickly and the system tuned within a short period for an uncomplicated transmission line system

I wonder how cases have occurred where an utility has actually had to change its designed PLCC transmission frequency because of an interference issue?

Talk to them

I found just by phoning up your local power utility engineering office and directly asking about PLCCs in use close to your location is the easiest way to go and the answers have always been positive. Turning on a radio and tuning thru the 50-500 kHz spectrum is just as easy but determining what a switched mode supply signal versus a PLCC is may be a little more difficult, but for sure if a PLCC is transmitting. We are fortunate here as we have a bit of a symbiotic relationship where Im used voluntarily to pin point or report on insulator of transmission issues – it helps them and helps me keep a clean RF environment.

Simple case studies looking at relative levels from/to PLCs (Section 175)

All information gained here is from public records and freely available

In the FCC-15 Section (also section 171) it talks about a study at 152 kHz and levels achieved

Studies by others tend to support a "safe zone" of distance of say 1 Km (ARRL technical analysis of 1985 NTIA technical report) and or perhaps limitation on power/ERP and or antenna height.

I thought I'd had a quick look at this in the field.

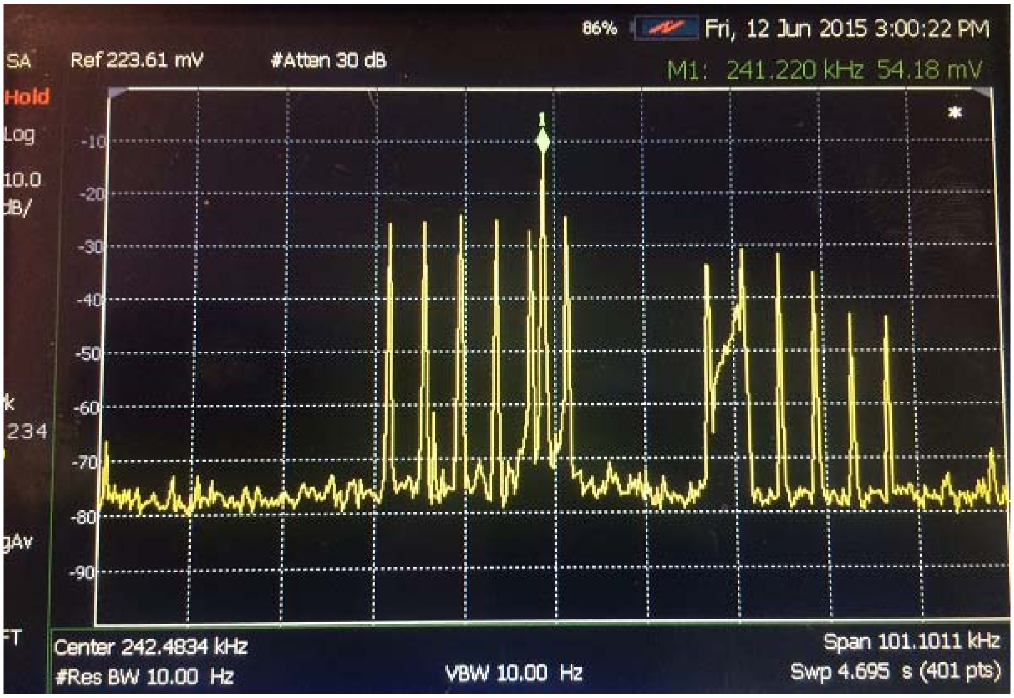
I took an example of our local Alaskan transmission system which is a mix of 115/138/230Kv and the PLCCs/carrier systems apparently used on that system. The aim being to ascertain how they radiated in real life and how near field/far field levels were produced and reciprocally how they reject outside fields

Note – all signal levels shown are relative not absolute -

The University substation in Mid town Anchorage carries an array of PLCCs/harmonic/Scada type waveforms in the 217/280kHz region, with a large central pilot carrier around 241kHz.

It's one of the hubs that transports power down to Kenai (Kenai line) and up the rail belt via Palmer/Wasilla – The grid is being hardened with new 230 Kv multi route transmission systems as power requirements increase, the network hardware updated, and new solid/gas fuel or hydro generation coming on line.


Survey site

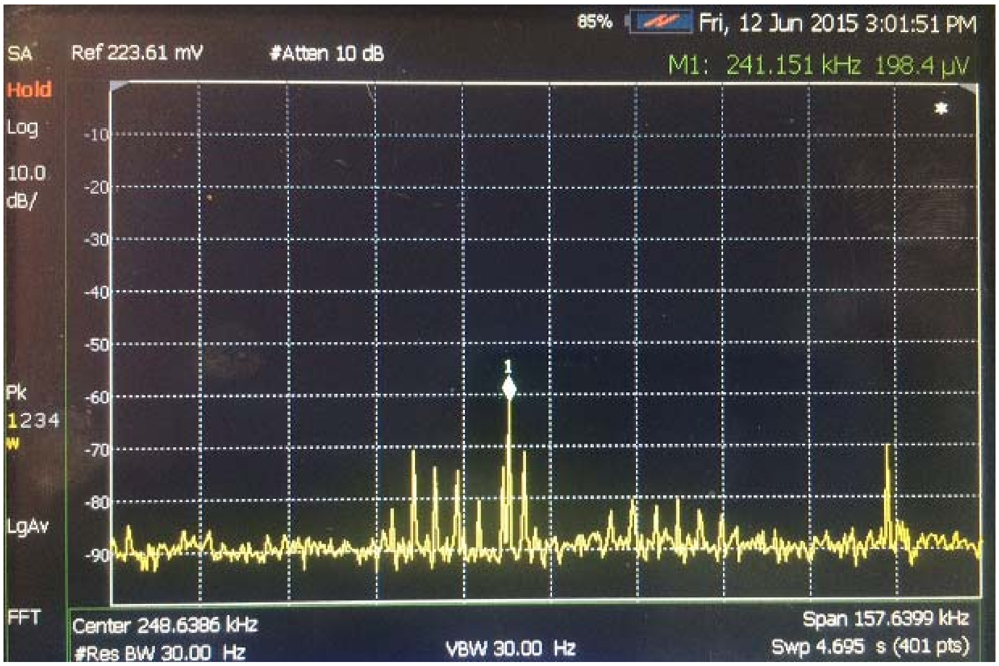


The spectrum above was obtained from public property under the power lines at the University substation. The *relative level* of the main carrier is 54.18mV at circa 241 kHz – this was just about 10 meters from the conductors using an Agilent Spectrum Analyzer and Probe with an AF of typically X4 at this frequency –the pilot being 200mV at 10m into 50ohms

Note: Some manufacturer's system power is actually increased ("to maximum power") when data or speech is being sent – typically transmitters have a 4 kHz channel separation often using suppressed carrier single side band and within a 4 kHz channel are a high power Pilot carrier, voice order wire from 300-2100Hz, and a data channel from 2150-3200Hz for data/tele-protection or other fault detection or function

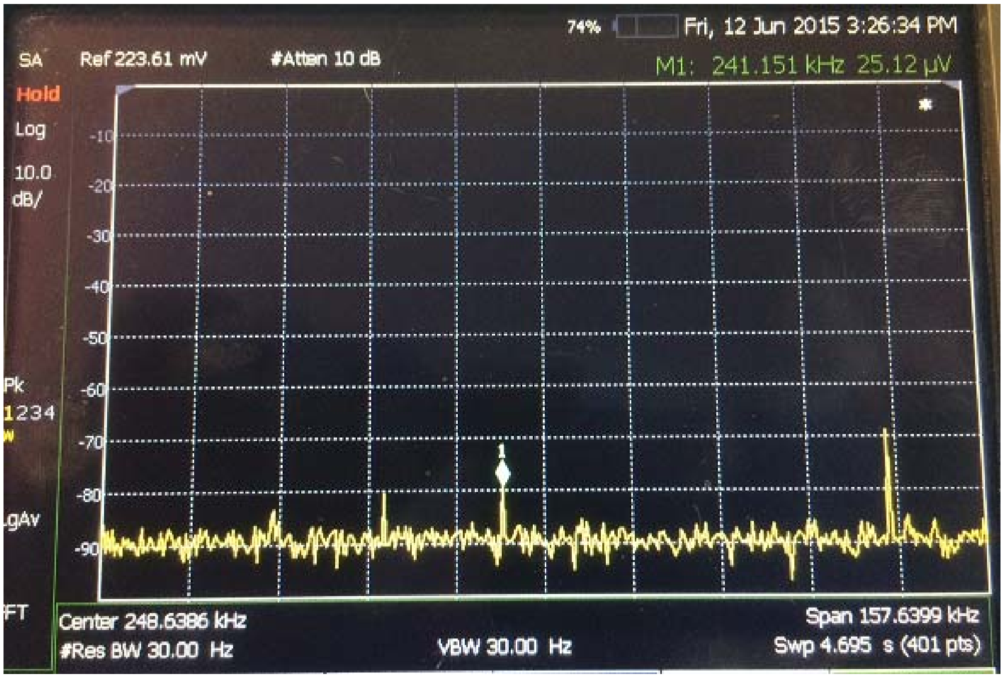
200m distance

And next the signals seen at 200m (by GPS measurement) parallel to the main lines and substation (I reduced the attenuation from 30dB to 10dB but the relative levels are still correct). This measurement was repeated each side of the lines and the levels were very similar. The 200m survey was conducted up Highway 1 past Eagle River up to the Eklutna generation station and the levels shown were also similar – driving up and down the line I didn't see a lot of standing waves so it looks like this line is pretty "flat"



And at 500m

(The two carriers either side of the marker are the non-directional beacons some 100Kms away and are masked close in but still visible at 200 and 500m) – We are down to 25.12uV from 51.8mV relative at 500m



Results and comment on the PLC survey (Section 175 condt)

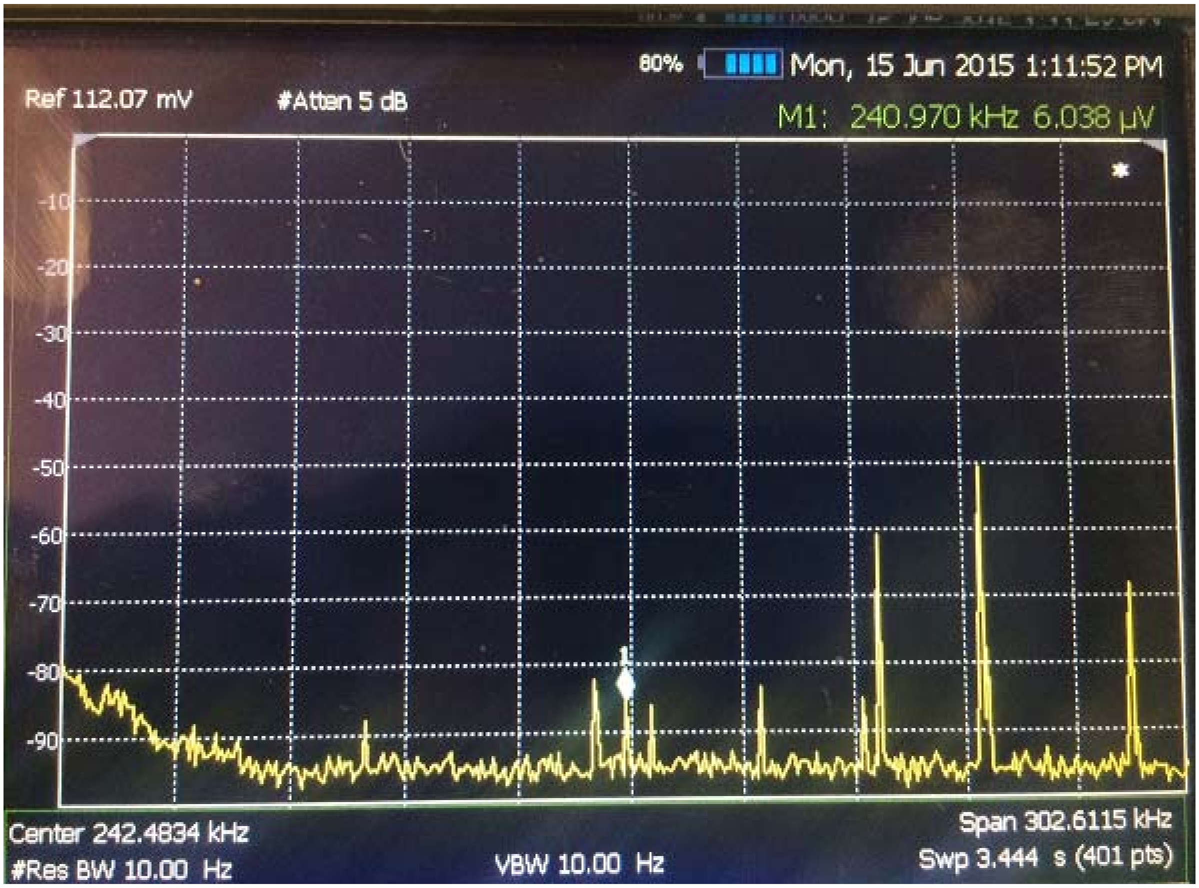
This is just a sample and one record, but typical from my experience of looking at the similar surveys in Oklahoma.– the actual levels are not that critical but the distance/drop off is in my view and supports the electrical features of a well terminated line.

We can argue near/far field and inducted E/V fields, but as you can see the scalar values, and real radiation portion of the PLCC signal drops off very fast, and on the reciprocal path so would any incoming unwanted signal.

Just a few hundred meters more I lost the signal in the local environmental noise from the survey vehicle.

The end of the line (Section 175 continued)

I did go the end of one 230 Kv line at a new substation up near Wasilla, but Im not sure whether the PLCC is designed to cover this location or whether the signals seen were passed thru or just coupled/stopped at the previous station. The PLCC signal is marker 1 was taken 200m from the line. The two signals either side and the signal above are all NDBs – the strongest trace is "CMQ" Campbell Lane on 348 kHz



Nulling out the noise – it cuts both ways (Section 168 and 175 condt)

Luckily I don't live under or near a pylon (or large wooden poles here in Alaska that are used for transmission lines) but I tend to look at it in another way of reducing interference **to** and **from** power lines be it PLCCs or other unwanted source (which in the bands we are discussing are very small numbers in limited physical locations where stations aren't likely to want to set up a radio station within a hundred meters, as paragraph 160 stated).

Beyond the height/power/distance limitation discussion by others - This part 5 station and others have experimented with high current small circumference (in relation to wavelength) transmitting loops, put up in trees or other structures, and gained a large insight into how you could null out power lines coupling or unwanted noise by in my case an additional 25dB within 300m, and 32dB at 1 mile at 137kHz –

If you inspect the Polar diagram **attachment 1** of the 137kHz transmit loop signal from WD2XDWs' we had clean nulls of over 32dB at 1 mile, and slightly less at 300m in the near field.

32dB down from a 1W EIRP signal plus free space plus coupling losses (into that terminated line that doesn't want to be coupled to) plus anti-aliasing/filtering is a lot of loss, and there won't be a lot of signal on the power lines at 200m let alone 1Km as realized by field survey tests to date.

So given the required PLCC signal to noise ratio >40dBm in some cases, 5mV min others, unlikely coupling of typically vertically polarized signals, free space loss, effective screening of typical power lines, and avoiding co-channel you may be able to run 5W EIRP on 475kHz, 1W on 137kHz by using phased verticals (a lot more space intensive maybe) or in our case the loop within a **much shorter distance than 1Km**

Certainly the work of Mssr Bill Ashlock, Mitch Powell VE3OT and this part 5 station and others we now have technically proven alternatives that could be deployed if we wanted to *further mitigate* unwanted coupling for less than 1Km.

Identification of and differentiation of power lines (Section 176)

In Alaska some High Voltage lines are supported by wooden structures, so they are not all steel– Ill normally look at the Voltage service by the size of the insulators, but some systems are designed for 230Kv but overbuilt and running at 115 or 138Kv– it's not uncommon here to have a lower 7.5Kv/45Kv distribution service running below Transmission High Voltage lines.

I don't think recognizing high voltage lines by amateurs is going to be an issue. Positively there are transmission maps freely available on the internet, and as we discussed previously a single telephone call will probably answer any power line transmission PLCC question.

Im my mind it's as easy as that.

Technical innovation

Part 5 and future Amateur experimentation on both the 475 kHz and 137 KHz amateur bands will propagate technical innovation and new engineering solutions to cope with increased suburban and rural noise pollution levels from switch mode power supplies, plasma TV sets, underground dog fences (horrid), and variable AC drives. Techniques to detect and communicate at very low signal to noise ratios will continue.

Further amateur radio and part 5 experimentation teams will continue their development in SDR, low bandwidth digital signaling techniques, also investigating propagation irregularities due to physical location, changing ground conductivities, geomagnetic and other solar effects on the D E and F levels,. Weve seen new (really new) receive and transmit antennae designs to cope with location and noise limitations, together with highly efficient Class D E amplifier designs.

Field strength measurement –

Measurement of ERP against transmit power against antennae size and location isn't necessarily an easy matter given the variation in typical amateur radio sites but one I support.

Here in Alaska my local losses vary seasonally with larger losses in the spring/summer when capacitive dumping due to trees and sap for higher impedance verticals nested in a Birch forest, hence why we looked at and deployed loops which are less environmentally affected by weather or environment.

Measuring E(I)RP using Antennae current and total system resistance is indicative for some antenna solutions –

Typically amateurs (and those experimenting here under part 5) are not in a commercial transmitting station environment so unwanted capacitive losses and unwanted reductions in electrical height normally means calculated EIRP/ERPs are overly optimistic

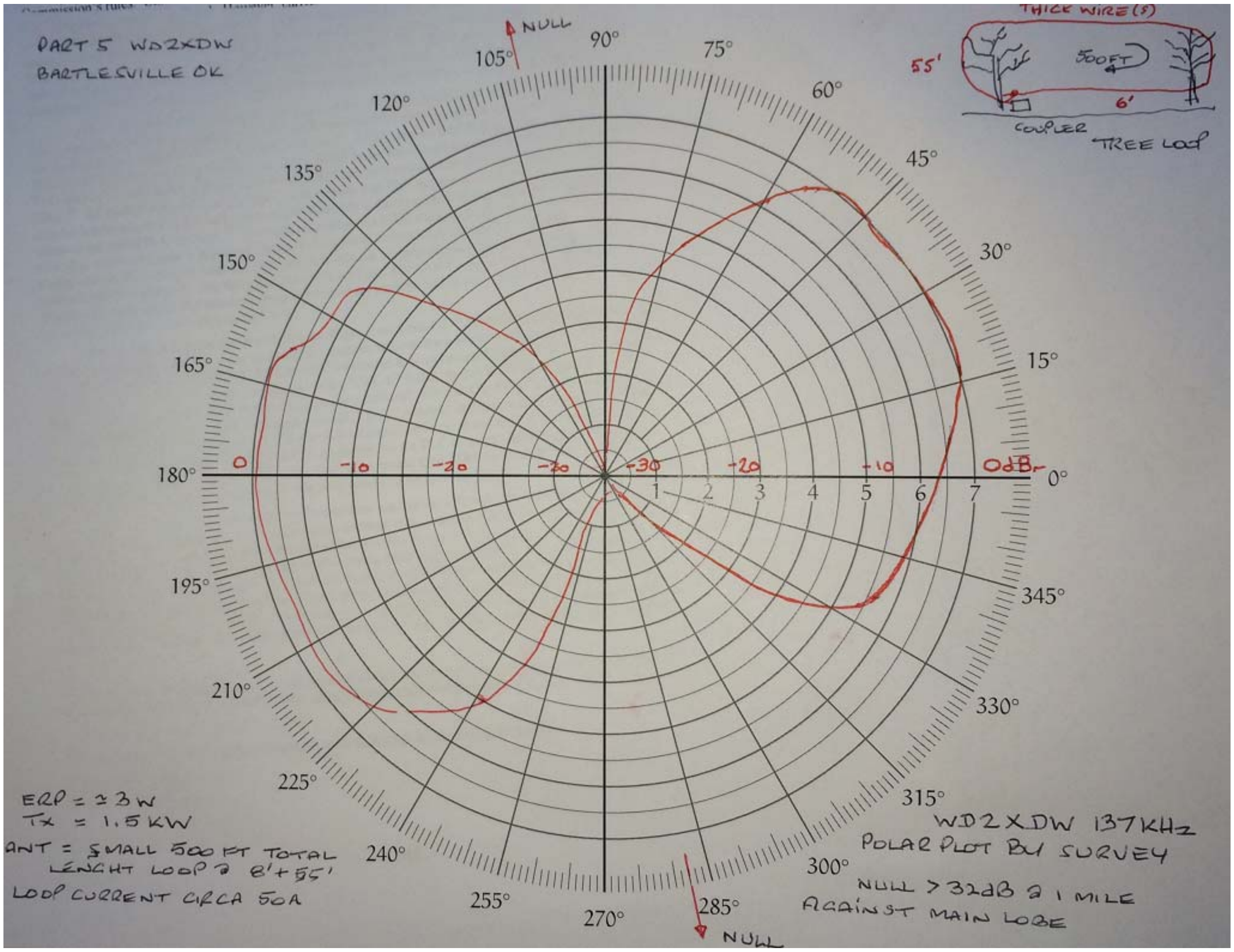
Sincerely

Laurence J Howell 15th June 2015 – Anchorage Alaska

Attachments follow

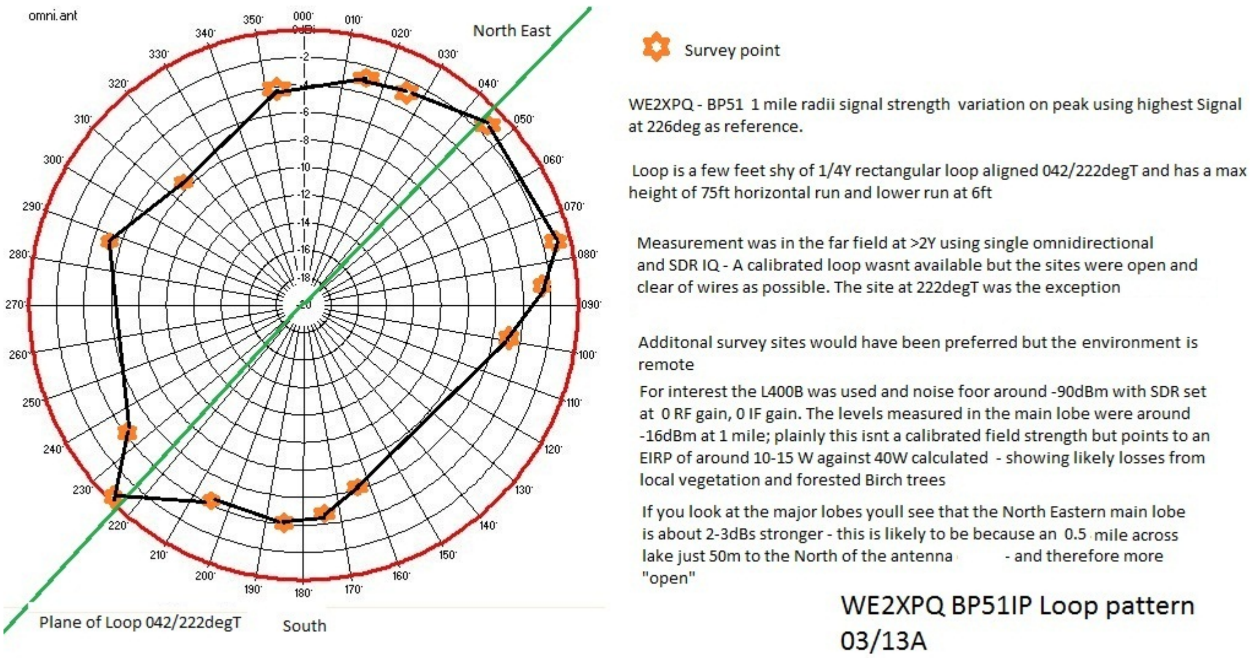
Attachment 1

Polar diagram of relative field strength taken at 1 mile of using a thick conductor (low loss at LF) small circumference transmitting loop (500ft) installed in a pair of Cotton wood trees.



Attachment 2

WE2XPQ transmit loop 500ft circumference radiation pattern at 506kHz (near quarter wave)



Attachment 3

WE2XPQ field strength (Multiplier AF=4) in dBmV 475kHz 200W 2A Marconi (XPQ Green house)
Anchorage is 60Kms – Summer (trees fully leafed)

Ends.