Comment Letter I29

From: Laura Buehning
To: Harris, Susan
Subject: Submission of comments on the DEIR for the Campo Wind Project with Boulder Bush Facilities
Date: Sunday, February 02, 2020 12:01:20 PM
Attachments: Manzanita WT Report - Body 2-24-13 FINAL.pdf
Manzanita WT Report - Appendix A 2-14-13 FINAL.pdf
Manzanita WT Report Appendices B,C,D 2-15-13 FINAL.pdf

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To: San Diego County Board of Supervisors and San Diego County Planning Commission
Re: Terra-Gen's Boulder Brush Facilities, Campo Wind and Torrey Wind projects proposed for the Boulevard/Campo Reservation area

I formally oppose these project due to their significant adverse effects to people's health, quality of life, economic well being, public health and safety, wildlife, ecological and groundwater issues.

I am a physician with previous or active board certification in dermatology, integrative and alternative medicine, and preventive medicine and public health (curriculum vita available on request).

For the past 15 years my work has focused on the area of bioenergetics. Bioenergetics is a field of medicine that evaluates the movement of energy in the body. It is widely known that the human body generates multiple electromagnetic fields such as muscle contraction (EKG and EMG), brain activity (EEG), membrane polarization and depolarization, and the mitochondrial electron transport chain [1]. Bioenergetics has also demonstrated that many molecular systems are sensitive to electromagnetic fields [1].

There is substantial evidence documenting the negative health effects of exposure to man-made electromagnetic fields (EMF). One of the most accepted and documented sources is the BioInitiative report [2]. This report has compiled multiple scientific papers showing adverse physiological mechanisms and specific diseases as a result of exposures to various frequencies in the EMF spectrum.

In regards to the proposed wind turbine projects, community members living close to the already existing wind turbine facility in this area, have reported multiple illnesses, including asthma, cancers, heart problems, inability to sleep and concentrate, and an increase in behavior problems among children [3]. These symptoms are similar to the reports from other communities living near turbine projects around the world, which has become referred to as "turbine syndrome."

To corroborate these complaints, an in depth analysis of electromagnetic fields at the Campo and Manzanita reservations was performed in 2012 [4] (A pdf of this report is included with this letter). This report showed elevated levels of electromagnetic fields including electric fields, radiofrequency radiation, as well as high frequency electric transients and harmonics (dirty electricity). It also documented that these harmful electromagnetic fields were primarily created by the existing nearby Kumeyaay wind turbines [4]. The author concluded that these levels were a significant health hazard to the surrounding communities.

In addition to this report, another assessment specifically of the dirty electricity component was performed by one of the world's leading authorities on this subject [5]. Dr. Milham has written the best known book on this subject [6] as well as many peer-reviewed scientific papers, only a few of his most relevant papers are referenced here [7-12]. He reported levels of transient voltage a thousand times higher than normal in this region (5). He recommended that "wind turbines should not be sited within 3/4 of a mile of homes, and that it would be prudent to delay wind farm construction until the utilities and the manufacturers can solve their electrical pollution problems".

In addition to these local effects, he explained that dirty electricity can also travel erratically through ground and interconnected waters on the ground and under it, making it difficult to predict how far, or where, it might propagate [5].

Milham later submitted written comments for an April 13 2012 planning commission hearing of San Diego County's proposed wind ordinance [13]. This communication included graphs of the stray voltage he measured at the reservation. He concluded, "it would be prudent to delay wind farm construction until the utilities and the manufacturers can solve their electrical pollution problems. Southern California Edison and other utilities now dump nearly 80 percent of their delivered electricity into the earth for return to the substations" [13].

Another important consideration in this project is the possible correlation between wind turbines and vibroacoustic disease [14-16]. Although this is a condition that needs further research and validation, it is important to note that many of the residents of the impacted community are reporting symptoms consistent with this syndrome.

To conclude, I believe that there are sufficient relevant issues to warrant the denial of the proposed project. Citizens in the affected community are already being adversely affected by the present wind turbine project and these issues could be significantly compounded by additional projects in this region. It is also important to stress that everyone is being affected by the adverse health consequences of our "electrification". I have found elevated levels of dirty electricity in every home that I have evaluated. Given the propagation of these electromagnetic fields, we are all being adversely impacted. This is not just a problem of a small rural community and Native American population, but a problem for us all. I believe that we need a better understanding of the health consequences and mitigation methods for these relatively new sustainable energy projects before we progress with more widespread and powerful projects.

Sincerely,
Laura Buehning MD MPH

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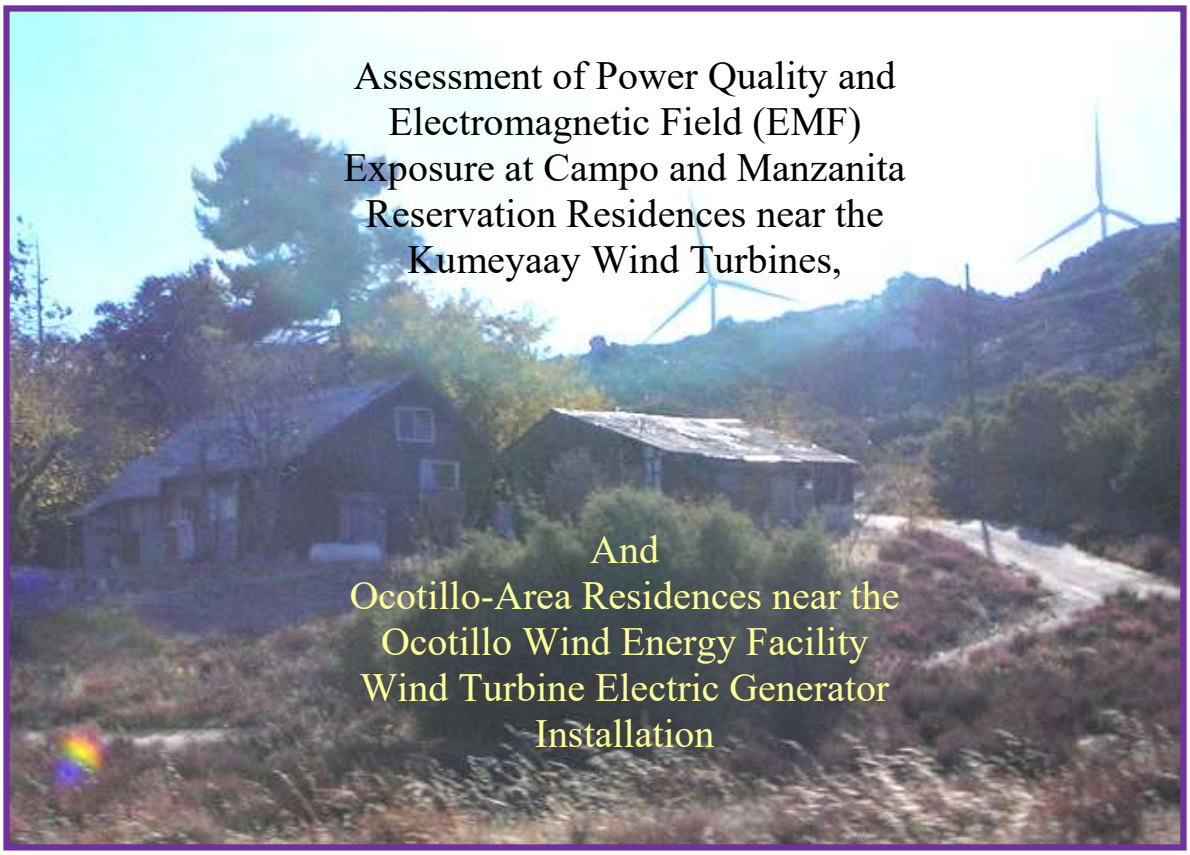

Assessment of Power Quality and Electromagnetic Field (EMF) Exposure at Campo and Manzanita Reservation Residences near the Kumeyaay Wind Turbines,

And

Ocotillo-Area Residences near the Ocotillo Wind Energy Facility Wind Turbine Electric Generator Installation

I29-7

Prepared For

The Protect Our Communities Foundation

PO Box 305, Santa Ysabel, CA 92070

Testing Conducted On
November 18-20, 2012

By

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(Document updated 2-2013)

Table of Contents

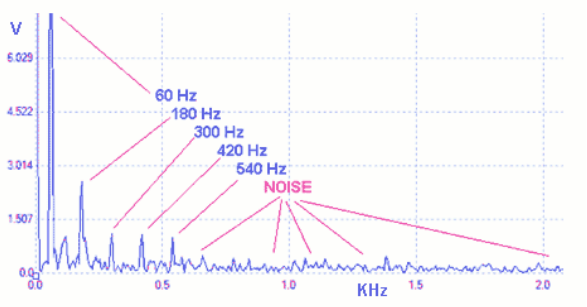
Disclaimer

This report is limited to electric fundamentals: Electric and Magnetic fields, Power Frequency Harmonics, and Transients, the latter two categories falling into what some define as electrical "pollution," and does not address any physical noise, infrasound, or other form of emissions that may be generated by industrial wind turbines.

This report is also preliminary and cooperation is needed from the turbine owners, SDGE, and the CPUC for more tests with the turbines and power off and on in order to clearly identify and eliminate the source of the electrical anomalies, and to ensure the safe and reliable delivery of electricity.

Executive Summary

The author was retained by the Protect Our Communities Foundation to visit the Campo and Manzanita Indian Reservations to: (1) test Power Quality and Electromagnetic Field (EMF) exposure at a variety of residential and comparison locations from the operation of 25 Gamesa 2-MW G-87 wind turbine electric generators at the Kumeyaay Wind Facility, and (2) measure the EMF exposure of two Ocotillo-area private residences and one open-desert comparison location prior to the operational commencement of 112 Siemens 2.3-MW wind turbines that have now been mostly installed as part of Pattern Energy Group LP's Ocotillo Wind Energy Facility.[1]



Testing was conducted with the permission of individual Manzanita and Campo tribal home owners, as arranged and witnessed by Manzanita tribal member Rowena Elliott. Owing to the author's distance from the investigation sites, Environmental Testing and Technology (**ET&T**) from the San Diego area, assisted in the investigation with the intent of possibly providing follow-up testing. During the days of testing near operating turbines, the wind was weak, late in the day, and few turbines operating. Because the cooperation of Infigen Energy (Kumeyaay Wind owner based in Australia), or San Diego Gas and Electric Company (SDG&E) could not be obtained prior to the testing, it was not possible to make EMF measurements during a fuller range of operational conditions.

Despite the involuntary constraints on testing, the measurements obtained were of high quality and were sufficient to identify numerous facets of the conventional residential electric supply near the Kumeyaay turbines that are anything but conventional – namely, inordinately high electric field strengths and substantial Electromagnetic Interference (EMI). The findings suggest that the high levels of EMF exposure at the tested residences are exacerbated if not primarily caused by (1) the expansion of the electric system web around the area's residents, including the Kumeyaay wind turbines and other electric generators and their interconnections, (2) the operation of and intermittent electrical generation from the Kumeyaay wind turbines, an (3) the immediate proximity of power lines to residences. As discussed herein, it is well demonstrated that utility-scale wind turbines, with their associated transmission and substation facilities, can and do cause the type of EMF exposure shown by our testing.

Because of the documented potential for significant adverse health and other effects from high levels of EMF exposure, as discussed further in this report, the author concludes this report with a discussion of some of the measures available to mitigate these harms.

Findings

Except for Mr. Ewing's Ocotillo residence, all other residences are modest dwellings of about 1000 square feet, ranch-style construction, with no basement. The Ewing residence consists of a separate home and garage, with the home larger than the others. The Ocotillo homes are built on what can be considered open desert, with the tribal homes built on rugged high desert land terrain.

[1] A separate Health Impact Assessment is being conducted with the Manzanita Band of Kumeyaay Nation through the National Latino Research Center at California State University, San Marcos, to determine disproportionate health impacts on low-income and ethnic minority population.

Except for Mr. Ewing's, all residences have an attached breaker panel mounted on a structural wall with outdoor access and are limited to 100 Amps. The Ewing residence had larger electric controls detached from the house.

All residences investigated employ NM / Romex indoor power distribution. This type of wiring allows the voltage resident on the conductors to produce an Alternating Electric Field through the insulating jacket. This is because the wires' insulating jacket (made of plasticizer-softened PVC), as well as Gypsum wallboard and most other structural components are transparent to the voltage-produced Electric Fields. These continuously pervade the living space, because all installed wiring is always energized, even if not in use.

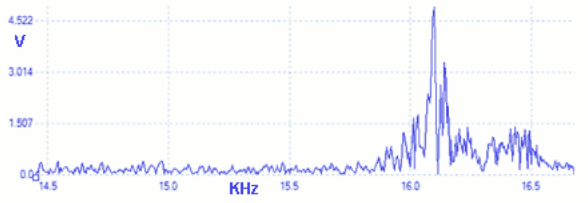
All residences investigated employ the common North American split-phase 120/240 V electric supply.

All residences investigated are interconnected to an aerial WYE electrical system. In this system there is a physical hard connection between the 7200 Volt Primary Neutral/Ground, and the 120/240 Volt Secondary Neutral/ground. In this respect, if there are abnormal electrical characteristics associated with the Primary Neutral they will be conveyed to the Secondary Neutral, and the residents served by them, without reduction.

Except for Site G, all residences had the 7200 V Primary distant from the structure and were at the end of a distribution circuit, or one of its branches. The Site G residence was constructed directly under the aerial Primary.

All residences displayed electrical characteristics within their electrical systems that are foreign to their electrical devices and related consumption characteristics. That is, these characteristics were detectable even with no power in use within the residences investigated (main breaker open/off). By virtue of the Electric field availability from installed wiring, all of these uncommon electrical characteristics (whether with power on or off) became a component of chronic personal exposure.

Some residents noted experiencing damaging interference with their electrical / electronic equipment. One individual remarked having to replace a well pump several times. High frequency harmonics or other frequencies using the electric system as a carrier were detected at this site.[2] High frequencies perform no useful work, other than perhaps heating (*precipitating equipment burnout*), when they are conveyed to a device engineered for 60 Hz exclusively. Another noted repeated EMI to television reception. Again, a high frequency presence was identified at this site on the electric system, and due to the type of electrical connection, external EMI is brought indoors without reduction. Some tribal members described the onset of various health issues that seemed to coincide closely with a certain time lag from the installation of the turbines, such as numerous cancers including stomach, kidney and brain.



However, formally ascertaining the cause-and-effect relationships between these maladies, and the presence of EMI and wind turbine operations is beyond the scope of our testing and this report.

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[2] **Harmonics in your electrical system -** *What they are, how they can be harmful, and what to do about them* – Eaton Corporation, undated - http://www.newark.com/pdfs/techarticles/eaton/Eaton_Technical_Articles/UPS_Training/Powerware_Training/HarmonicsInYourElecSystem.pdf
Hazards of Harmonics and Neutral Overload - *a Schneider Electric White Paper*, 2011 - http://www.apcmedia.com/salestools/SADE-5TNQZ5_R1_EN.pdf

Although the scope of testing was limited, preventing us from conclusively determining the ultimate source(s) and propagation pathway(s) of the measured EMI, the most likely sources appear to be the Kumeyaay wind turbines and associated electrical substation and power distribution facilities. The most likely pathways are through ground currents, via the aerial distribution primary, and through the air when in closest proximity to the turbines. This may be considered pollution in an otherwise 60-Hz-only environment where it may interfere with various forms of sensitive electronics, or life forms whose sensitivity is heightened for whatever reason.

Discussion

The authors documented Alternating Magnetic and Electric Field backgrounds, Radio Frequency (**RF**) background, Neutral-to-Earth Voltage (for the system Neutral), and Wide-band Emission character of each field, where possible.

The most notable finding is that all residences at which measurements were taken displayed substantial Electromagnetic Interference (EMI) within their electrical systems that were foreign to their electrical devices and related consumption characteristics.[3] The Electric fields were also inordinately strong, even reaching extreme levels in certain locations like Site G (~700 V/m) due to the presence of the 7200-V aerial distribution primary.[4] RF was relatively high, considering the rural character of the community. While Magnetic fields were minuscule, they were also dynamic in character and wideband, i.e. varying constantly and spanning a significant portion of the frequency spectrum.

All fields were below officially recommended exposure guidelines that are based on Thermal considerations or short-term (acute) effects, yet by virtue of the electric field availability from the installed wiring, all of these uncommon electrical characteristics (whether with power on or off) enter the living space and become a component of chronic personal exposure for the residents.

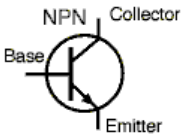
The EMI encountered may be associated with the Ground / Grounding current as described in Appendix D [3, 4] where current is flowing between grounding points of different voltage levels, and may be cause for current to flow from the ground wire into the soil, or from the soil into the ground wire, solely dependent on the instantaneous value of the grounding point voltage relative to the soil. The EMI encountered may also be carted about by the Electric Primary 7200-V power distribution system, which serves as a convenient antenna, to acquire it at one location and redistribute it to others. This EMI can thus migrate into homes and other occupied structures through power distribution lines, ground currents, and through the air, when in closest proximity to the source(s).

The most powerful sources of EMI in the area are suspected to be the Wind Turbines, by the means they produce power.

A brief Internet search on December 16, 2012, for a Gamesa 2.0 MW turbine disclosed the following:
Gamesa 2.0 MW catalog - October 2012[5]
Control system: Maximum output under Any wind condition. Dual powered generator, speed and power controlled by **IGBT** converters and electronic **PWM** control (Pulse Width Modulation).

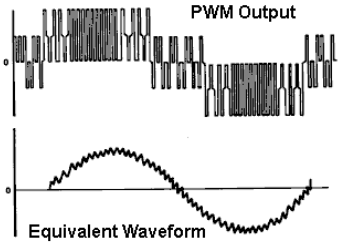
[3] We confirmed the foreign origin of the EMI when we repeated our measurements with the power to the residences turned off (main breaker open/off) and still detected EMI.
[4] Because the distribution primary is solidly referenced to ground, it can spread electric fields more than 300 feet radially from the power line in the absence of tree buffer, which attracts the electric field lines and shunts them into the ground due to the intimate root-soil contact.
[5] http://www.gamesacorp.com/recursos/doc/productos-servicios/aerogeneradores/catalogo-g9x-20-mw-eng.pdf

An **IGBT** is a Field-effect Transistor. In the world of electronics there are two types of transistors, Point-contact as shown to the right, and Field-effect.



The Point-contact type is known as a **Bipolar Transistor** or **BT**. BTs have a limiting power rating.[6]

The Field-effect type known as an **Insulated Gate Bipolar Transistor** or **IGBT** for short, function by electrostatic action and are essentially a switch that is either on or off, and is shown schematically and pictured below. The thermal limitations of the Point-contact device are not present.[7] However, to properly employ the features of an IGBT, any desired analog output waveform has to be synthesized from digital means. In order to produce a smooth-appearing output waveform, filtering is used to smoothen an otherwise very erratic output, as shown to the right, also on page two of Appendix B, and commonly known as **Pulse Width Modulation** or **PWM** for short.



The IGBT to the left is limited to 30 Amps and 900 Volts, or 27,000 Watts of throughput! *Source: Wikipedia* Perhaps not unlike what may be used in the wind turbine generator exciters.

A typical switching frequency for an IGBT is 30,000 Hz. This is equivalent to turning a switch on and off 30,000 times per second. A dimmer switch, in contrast, turns power on and off to its controlled device(s) at a frequency of 120 Hz. A faster switching frequency requires a steeper waveform. The steeper the waveform, the greater the number of Harmonics required to produce it. Some of the peculiar side effects of the associated components of this PWM are: 1) a spread of the harmonics across the Radio Frequency (RF) spectrum, as easily detectable with an AM radio, or suitable spectrum analyzer, and 2) induced voltages and currents onto anything electrically conductive within reach of the incident field. The latter, as described in the Aegis literature referenced,[8] involves a process whereby the induced voltages and currents cause **Electric Discharge Machining** (**EDM**, a process with much similarity to welding) of the generator bearings and the races they fit into (apparently due to inadequate filtering), truly an Achilles' heel. To prolong the life of a generator with PWM input, a shaft collar with conductive nanotubes (to increase the contact surface area) was developed by Aegis to short these induction effects to ground. Aegis' testing, indicates the harmonics span to several MHz. The uncontrolled presence of these harmonics across the spectrum constitutes Electromagnetic Interference (EMI) with anything using that portion of the spectrum intentionally or under license to do so.

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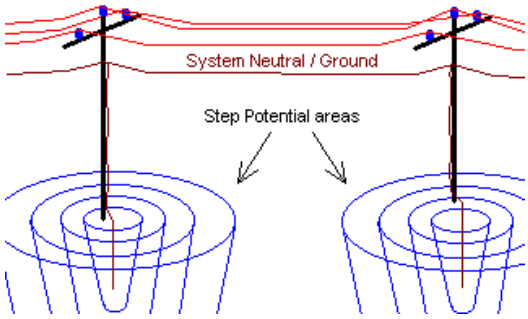
[6] Wattage = Voltage across the device x the Current through the device, or W = V x C. So when a BT has 20 volts across it and 2 amps through it, it is instantaneously dissipating 40 Watts of power, and requires a substantial heat sink to prevent immediate failure. Common heat sinks can be found at the rear of many audio amplifiers, as solid metal fins that get warm during use, because the output power BTs require adequate cooling.

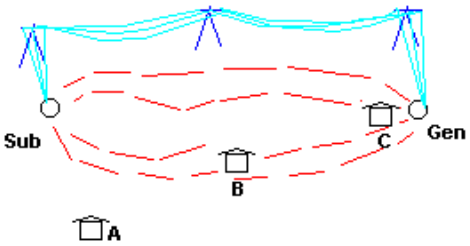
[7] When considering the relationship of W = V x C, during IGBT operation, the Voltage is zero (fully on, and maximum current) rendering zero power dissipation across the transistor, or the Current is zero (fully off, and maximum voltage) rendering zero power dissipation across the transistor.

[8] **Aegis - Preventing Generator Shaft Current Damage** - William Oh - Electro Static Technology, 9-2006 - http://est-aegis.com/TechPaper.pdf

Considering a typical .5% of the generator output being required at the exciter to provide stable operation would imply .5% of 2,000,000 Watts (2 MW), or 10,000 Watts (10 KW) of PWM power being fed to the exciter. All harmonics associated with this IGBT-fed exciter, at each generator, would need to be filtered, and induction effects shorted to ground. When anything electrical is shorted to ground, there is a cone of influence, much like an inverted ice cream cone, around the point of contact that expands with decreasing strength as one moves away from the point of contact horizontally, as well as vertically downward. When there is a nearby point (within a mile or so) that has a ground contact with dissimilar voltage (*due to the intrinsic resistance of wiring and the current flow through it*), current flows between the two as a Ground Current of definite but erratic and unpredictable path. When someone is within or near the cone of influence above the soil, it is easy to measure the voltage differences with earth contacts, or detect free-space magnetic fields that mimic the flow of current in the soil when sufficiently away from the aerial power line's influence.



When these large power generators, be they wind or solar, are built close to residences, the impact can vary greatly depending on the proximity to the residences. As shown in the oversimplified sketch, the house at location "A" is distant from the intended route between the generator and substation. House "B" is distant from the intended route, but is encroached upon by the unintended route via the ground current, the dashed route. House "C" is encroached upon by both the intended route, and the unintended route. The author is keenly aware that since economics drives all facets of such installations, the least-cost route will be chosen. So some thought may be given to exposure concerns to house "C" because it is obvious, but no concern will be given to study possible ground current effects, so house "B" may be impacted, despite the best-intended efforts at being "community-conscious" by considering the effects for house "C."



<u>The Kumeyaay Wind Facility Is Likely a Primary Source of the Measured EMI in Tribal Homes</u>

The EMI measured in the Campo and Manzanita tribal residences is likely produced primarily by the Kumeyaay wind turbines and associated facilities. While, as discussed, it is beyond the limited scope of our testing and this report to conclusively determine the ultimate source(s) of the measured EMI, the available evidence points strongly towards the wind turbine facilities as the primary source for at least three reasons.

First, as discussed above, wind turbines exciters produce substantial induced voltages, currents and broad spectrum harmonics that frequently manifest as EMI in the electrical systems of nearby residences and other receptors. And as explained, these electrical irregularities often stem from the use of

IGBTs and pulse width modulation (PWM). Those same mechanisms are used here, probably with the same effect. According to Gamesa's own literature, "speed and power" of its 2.0-MW turbines are "controlled by IGBT converters and electronic PWM control (Pulse Width Modulation)"[9] (p. 16).

Second, the WYE power distribution design of the measured tribal residences (whereby there is a hard-and-fast connection between each home's supply transformer primary and secondary) is such that any voltage irregularity produce by the Kumeyaay turbines and present or induced in the long-distance route of the circuit will be brought directly into each home without reduction.

Third, there appear to be no other nearby sources capable of producing the magnitude of EMI measured at the tribal homes. According to knowledgeable area residents, there are no other energy-intensive industrial or commercial uses nearby that could have produced the EMI. The one possible exception is the Golden Acorn Casino. But the casino is operating under minimum occupancy and correspondingly minimal electrical load, and it is thus unlikely that it contributed much if at all to the measured EMI.

It is also unlikely that the residents themselves contributed more than minimally to the measured EMI. We confirmed the foreign origin of the EMI when we repeated our measurements with the power to the residences turned off (main breaker open/off) and still detected the EMI.

Due to the current transformation between any transformer's secondary (120/240) and the primary (7200), even 60 amps generated at the customer's premises translates to only one amp on the primary side. And because, like the residents at the sites investigated, the majority of tribal residents live in modest homes, it is unlikely that they would even generate the typical residential load of 7 amps per phase. This indicates that their contribution to primary load and subsequent N-E voltage would be minimal, strongly suggesting that the major, and possibly only, source of EMI would be industrial and/or energy-intensive commercial uses, with the Kumeyaay wind turbines and associated facilities being the most likely candidates.

Given these three factors, it is not surprising that the characteristic electrical irregularities produced by wind turbines closely resemble the EMI measured at the tribal homes.

The production of electromagnetic interference (EMI) can be propagated by way of **Conduction** (where the EMI travels within or along the surface of a conductor) or by **Radiation** (whereby the energy frequency content is fast enough for it to travel in free space). Whether by Conduction or Radiation, the infrastructure is present to support both. Additionally, there is a region in space whose dimensions are dictated by wavelength, which is designated as the "**Near Field**," whereby even without radiation, energy is transferred from source to victim receiver by immediate proximity to the source field. The wavelength of the frequencies detected varied from about 3100 miles for 60 Hz to about 180 feet at 5 MHz, placing all conductive structures within the near field of the turbines except for the highest frequencies detected. The nacelles being located high aloft places them at ideal position to convey EMI onto the surrounding countryside, and use the distribution lines as convenient antennas that will pick a portion of the radiated energy and redistribute it far from the sources. The grounding necessary to protect the generator bearings, introduces unusual ground current characteristics whose paths we could not adequately map or quantify, due to time and location constraints, providing for conduction propagation via every grounded electrical device in the surrounding area to act as a party to the conveyance between grounding points.

[9] http://www.gamesacorp.com/recursos/doc/productos-servicios/aerogeneradores/catalogo-g9x-20-mw-eng.pdf

As time passes new technologies are introduced whose utility is embraced without concern for possible consequences, until . . . someone realizes a connection with the new technology and disease, and questions are raised. In 2001 one such connection was published between childhood Leukemia for ages 2-4 and electrification. Electrification was introduced in North America around the late 1920s. The connection was realized some 80 years later, via historical data.[10] Along the course of this discovery, when evidence was sought, it was sometimes suppressed, or destroyed.[11] The study's authors implicated alternating Magnetic fields based on their understanding. The author of the present document would like to suggest that during early stages of electrification magnetic fields were minuscule, but electric fields were at maximum value, the same as they are today. The incubation period for the disease trigger mechanism to develop can then be less than two years, for susceptible individuals. In 1996 a study was published of research among electric utility workers whereby over 30,000 workers were tracked for over 15 years as to their occupational electrical exposure and occurrence of disease. The clear connection emerged between exposure and various forms of Leukemia, showing a dose-response for increasing exposure to Electric fields. While the authors stated that "the analysis have to be interpreted with caution," they also stated that due to the peculiarities of Electric field measurement the "association in practice may even be stronger than that reported."[12] The incubation period for the disease trigger mechanism for adults in the general population is unknown due to many variables. Both studies noted are suggestive of Electric Field interactions.

Clearly, we would want to have absolute certainty before making rash actions that could curtail commerce and put people out of work. So application of a **Precautionary Principle** is appropriate, albeit conservatively. However, "its potential impact on trade means that its application can have global repercussions. One early application in Europe was by Dr. John Snow, who in 1854 recommended removing the handle from the Broad Street water pump in an attempt to stop the cholera epidemic that was then ravaging central London. Some evidence for a correlation between the polluted water and cholera had been published five years earlier by Snow himself (Snow, 1849). This evidence was not 'proof beyond reasonable doubt'. However, it was proof enough for Snow to recommend the necessary public health action, where the likely costs of inaction would have been far greater than the possible costs of action."[13] - Absolute certainty, however, is clearly impossible in some cases.

The Magnetic and Electric field exposure limits criteria might infer that we can sit inside an operating transformer and remain healthy, as:

"Maximum exposure limits are based on avoidance of the following short-term reactions:
a) Aversive or painful stimulation of sensory or motor neurons,
b) Muscle excitation that may lead to injury while performing potentially hazardous activities,
c) Excitation of neurons or direct alteration of synaptic activity within the brain,
d) Cardiac excitation,
e) Adverse effects associated with induced potentials or forces on rapidly moving charges within the body, such as in blood flow."[14]

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[10] Historical Evidence that Residential Electrification Caused the Emergence of the Childhood Leukemia Peak - S. Milham, E. M. Ossiander – 2001 - http://d1fj3024k72gdx.cloudfront.net/historical_leukemia.pdf
[11] Dirty Electricity – Sam Milham, MD, PHD - Publisher: iUniverse, 2010 ISBN 978-1-4502-3821-2
[12] Leukemia following Occupational Exposure to 60-Hz Electric and Magnetic Fields among Ontario Electric Utility Workers Anthony B. Miller et.at. January 1996 - Evaluation of the combined effect of electric and magnetic fields for leukemia showed significant elevations of risk for high exposure to both, with a dose-response relation for increasing exposure to electric fields and an inconsistent effect for magnetic fields. http://www.ncbi.nlm.nih.gov/pubmed/8678046
[13] Late Lessons From Early Warnings - The Precautionary Principle 1896–2000 – European Environment Agency - ISBN 92-9167-323-4 © EEA, Copenhagen, 2001
[14] C95-6 IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz

Ironically, exposure to any alternating field will cause the very thing happening within a transformer, for all individuals exposed. When an electrically conductive structure (which includes humans) is exposed to a field of any kind with **relative motion** to the structure, what occurs is **Transformer Action / Action at a distance / Induction**, which causes internal and external currents and voltages to the structure. When the source is not physically moving but the components (voltage, current) are changing, and their reach extends onto a conductive structure, the relative motion criteria is satisfied. With humans, this will be voltages and currents produced internally and externally to the body. While most individuals do not directly feel these currents and voltages, they nonetheless produce effects which may be immediately unpleasant, and whose end-result is interference with ongoing chemical and electrical processes within each individual. Any interference with normal processes has the potential to bring about errors in process that as an aggregate constitutes disease. And most unfortunately, while the "safety" standards provide some protection from imminent danger, they do not address chronic or cumulative exposure resulting from an ever-increasing invasion of our residential, workplace, and remaining natural environments. In the minds of the IEEE, that is because:

a) There is not sufficient, reliable evidence to conclude that long-term exposures to electric and magnetic fields at levels found in communities or occupational environments are adverse to human health or cause a disease, including cancer.
b) There is no confirmed mechanism that would provide a firm basis to predict adverse effects from low-level, long-term exposure."[15]

However, "The lack of a reasonable explanation is not a trivial distinction, since there is great reluctance to accept observational evidence, regardless of replications and the number of supportive reports, without a reasonable biomolecular basis."[16] Further, "Ion cyclotron resonance (ICR) as it applies to biological systems was first discovered to be a critical underlying factor in connection with previously observed electromagnetically-induced changes in free calcium in brain tissue (Ca-efflux experiments)."[17] And "Because these ICR effects appeared to violate simplistic analysis involving magnetic induction at first they evoked much suspicion in the scientific community. Many subsequent confirmations, however, performed on different model systems in diverse experimental situations , . . . , proved that these weak low-frequency effects are indeed real."[18] "One explanation is that this effect likely reflects the endogenous nature of bioresonance, wherein multiple ion resonances are occurring simultaneously giving rise to a balanced physiologic outcome."[19]

"The description ***non-inductive non-thermal*** helps emphasize that the effects obtained by applying low intensity low-frequency electromagnetic fields to biological systems are not the result of either inductive emf generation or the delivery of thermal energies through Joule heating. By contrast, a number of clinical devices that make use of Faraday induction or Joule heating are recognized by the medical community not only because they are effective, but also because the applied voltages, currents or heat are fully consistent with what is expected biochemically. In sharp contrast, the non-inductive non-thermal category includes clinical applications where this is not true, that is, where the electromagnetic variables that are part of the therapy fall outside those permitted by the current medical paradigm."[20]

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[15] C95-6 IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0–3 kHz
[16] **Electromagnetic Medicine Non-Inductive Non-Thermal Modalities** (Supplement 2012), Abraham R. Liboff, PhD, Professor Emeritus Department of Physics Oakland University Rochester Hills, Michigan USA - Prepared for the BioInitiative Working Group September 2012 (Bioinitiative Report 2012, p.1112) http://www.bioinitiative.org/
[17] Ibid, p.1113
[18] Ibid, p. 1114
[19] Ibid, p. 1115
[20] Ibid, p.1111)

Notably, even from the briefest excerpts quoted from the IEEE C95-6 standard, all exposure standards are based on induced emf (voltage and / or current) and thermal (heating) effects. These predecessors to these exposure standards were devised in the middle of the 20th century to protect personnel who were displaying symptoms after acute exposures. Since trying to produce guidelines for long-term effects was not within these agencies' capabilities, short-term limits were set exclusively, with erroneous assumptions for long-term exposure effects, which are now becoming obvious.

There is a community at large, working to eliminate "dirty" energy generated by fossil fuel power plants and the related air pollution. Not that electricity can be dirty in the sense that one can easily clean it up, but rather that it has some quality that was not originally intended. And, expectedly, there are some hucksters trying to make a quick profit with the lore of a clean and green "solution." Yet, as complex as the electrical "dirt" may be, so is the "solution," which brings on additional complex technical problems. The real "dirt" in electricity is non-linearity in the waveform, in that the end-result of some usage causes deformation of the original waveform provided by the utility (in North America a continuously alternating voltage at 60Hz), as well as additional frequency components which are required to produce that deformation. The more radical the deformation, the more frequency components are required. As an example, a simple charger for a personal computer can produce additional frequency components (or harmonics of the power frequency provided to it) that span the entire range from 60 Hz to the MHz range. That is, from 60 cycles per second to well over 1,000,000 cycles per second. All of the exposure guidelines do not take into account the presence of harmonics from a biological exposure perspective.

Some of the sites visited allowed both the test group and homeowners to clearly hear the motors used to rotate the blade direction to optimize output, as well as being in the electrical near-field, as referred to on page 9 of this document. Such close proximity to residents cannot be implied as being anywhere close to "clean and green," as it may be for individuals living 10 to 20 miles distant, where the ground currents and induction effects from the generators get lost in the urban electrical noise background. Testing was performed solely during daylight hours, but it is obvious that if the wind is blowing during nighttime the same physical noises heard during daylight will also be present during time when individuals try to sleep. Sleep disruption is one of the worst possible effects, because when an individual fails to achieve restful sleep, their daytime functioning may be impaired. While Solar Power projects have the promise of eliminating the physical noise component to some extent (except possibly Aeolian vibration as the wind passes the various structures), electrically they may be as problematic as wind turbines, because the output of solar panels is direct current, and the transformation to alternating current for long distance cartage is an electronic synthesis, perhaps not much different than the wind turbines'. While the author cannot delineate a distance that is comfortably "safer," it is clear that placing industrial-scale wind and solar projects at least a few miles distant from all neighbors would eliminate the most significant electrical near-field effects, reduce or eliminate physical sound perception (partly based on topography, as sound produced in a valley can echo to all distant sides), and reduce or eliminate ground current contributions to residents.

What should be apparent from the material above by Professor Liboff is that the human metabolism is far from the simplistic machine of interconnected parts as commonly considered by many branches of medical practice. The human metabolism is a design, elegant beyond description, of many subsystems (some of which have been deemed by some "scientists" as "vestigial," or useless) which function separately, but in concert, to produce what we know as "life." When we consider that life to be a concert of many interrelated bioresonances due to the varied chemical compositions of our many subsystems, it begins to make sense why the amount of electrical "dirt" can be so irritating and potentially harmful, as appears to be the case in the sites investigated relative to this document. Resonance interactions can

occur at signal levels that are quantum leaps lower than brute-force exposure levels, such as those required for thermal effects. The copious availability of many simultaneous frequencies introduced into our systems from without are chaotic at best, with amplitudes that shift regularly owing to how many devices are involved in producing them, confounding the "dirt" with accompanying modulation by other frequencies. And because of our slightly different chemical makeup, the reactions will vary slightly among individuals.

One of the possible end-results of exposure to the various EMFs is Leukemia, if one were to believe the growing body of independent credible research on a global scale, giving the naysayers no valid excuse. The rate of leukemia is about 10 per 100,000,[21] and while it is a rare disease, it is nonetheless devastating. It is a fundamental attack at one or more of our core systems, so various other ailments will most likely precede its occurrence. Yet those succumbing to the illness are often considered "anecdotal" because "scientists" do not understand or have confirmed the mechanism of their demise, when environmental exposures such as EMF may contribute risk. Yet with abundant and credible scientific research having taken place to prove cause and effect, when there is even an inkling of increased risk due to some exposure, and avenues to reduce that exposure are available at no or low cost, they should be implemented. Doing otherwise is nothing short of idiotic. It was not long ago in the historical past that various cultures sacrificed their children to various gods. Although we claim to be "civilized," "moral," and "technically advanced," we may be no different than our predecessors, when we accept the sacrifice of children to an electrical god, when simple precautions globally employed would reduce that risk to zero.

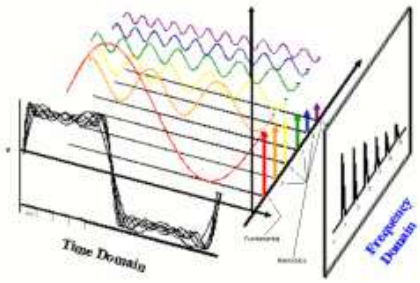
It is in the best interest of anyone subjected to Alternating fields of any level and frequency to reduce them to the greatest extent possible following the **ALARA** principle (As Low As Reasonably Achievable), because the available research strongly suggests that there is no safe minimum exposure.

Electric Field reduction indoors can be achieved inexpensively by removing energized devices from the bedside (lamps, alarm clocks, radios, etc.), and using day lighting as much as possible during waking hours. **Electric Field reduction outdoors** is greatly aided by tree plantings, as they are in intimate contact with moist soil (grounded), are conductive, and shunt the electric field from a source on one side, preventing a field presence on the other side. This is especially effective when the trees are planted between a house and a nearby power line. This is an electrostatic effect and does not increase ground current. **Magnetic Field reduction from ground current** is difficult to accomplish at the individual level owing to the many sources interconnected to the soil, and Neutral Isolation from the supply transformer will greatly help to reroute long-distance cartage of ground current to/from sources, and especially away from residences. **Magnetic Field reduction from wiring errors,** which are common indoors, is easily accomplished per the protocol included at the end of Appendix B. **Wideband Emissions reduction** is at the core of the biological exposure due to many frequencies involved that are also themselves changing amplitude dynamically depending on what device(s) is(are) energized at any moment in time. Thus Neutral Isolation will help in part from a communal level, regardless of the source, and individual measures as described below will help at the individual level.

Testing was performed with expediency and with the intent of acquiring meaningful data with minimum testing. This prevented a full spectrum of all tests performed equally at all sites, even given their differences that prevented some testing from being performed in the first place.

[21] Leukemia and Lymphoma Society – http://www.lls.org/diseaseinformation/getinformationsupport/factsstatistics/leukemia/

Conclusion and Recommendations



Comparison of signal analysis between time domain and frequency domain
Modified from:

The authors employed magnitude, waveform, and frequency spectrum capturing equipment to document the presence of an extensive span of power-frequency harmonics, as well as other frequencies that are not associated with residential electric usage of any form. Some frequencies detected appear to be associated with electrical motor brushes as used in turbine exciters.[22] A few of these may even be produced by individual residential users and minimally shared among them[23] by the power distribution system as built, while testing with user power turned off identified that in most instances the electric non-linearity being brought in was still present and much greater in frequency span than that being locally produced by the owners at the premises investigated. Some of these components cause ambient multi-frequency EMF exposure even distant from any electric infrastructure.[24] While both authors collaborated to eke out meaningful data in an EMF-hostile environment, the opinions expressed herein are those of the principal author.

Alternating Electric fields abounded outdoors, in several cases at extreme levels, as well as indoors. The RF background was considerably high for a rural environment, and no directionality was acquired. While ET&T remarked that the levels were low, the author has on regular occasions detected RF levels decades lower in intensity. So it remains that RF levels were present from some undetermined source(s).

The author hypothesizes that many of the Magnetic, as well as Electric, interactions are frequency-dominated effects, especially where levels are high, as for Electric fields that were quite strong at most sites. When one considers that most of the common power frequency harmonics are within the human hearing range, it is not very speculative to realize that exposure to these fields can elicit auditory nerve response, such that individuals may “hear” sounds brought about by the field character, quite like air pressure variations, which is the more customary expression of sound.

Although the authors worked under restrictive guidelines, with a far-from-complete assessment, even the limited results and the ubiquity of the EMI seems to implicate the turbines, in that whether due to ground current, or induction in nearby power lines, the electrical components are carried to nearby and distant residences.

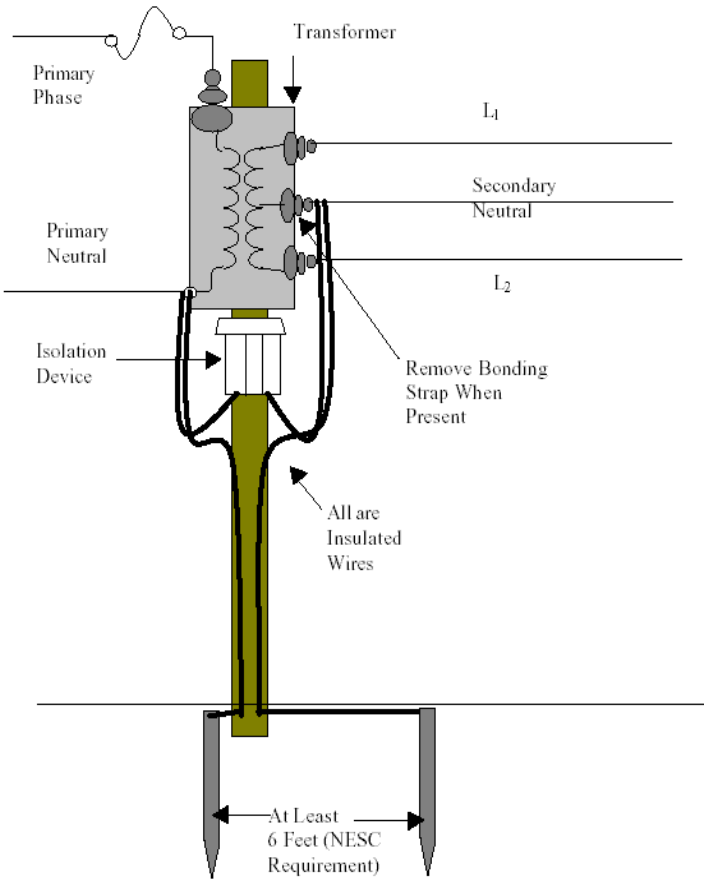
Because of the numerous demonstrated links between irregular electromagnetic field exposure and leukemia and other maladies, combined with the likelihood that many more health impacts from EMF exposure have yet to be discovered, the author recommends the implementation of the following mitigation measures to reduce wind turbine-generated EMF and the negative health impacts thereof, both here, with regard to the Kumeyaay Wind Facility and the Ocotillo Wind Energy Facility, and in future projects. Most suggestions offered herein are low cost, and easily implemented, with the general intent to reduce / eliminate: 1) the Electric field exposure, and 2) the wide-band content and exposure.

[22] Uptower Testing of AEGIS WTG™ Wind Turbine Bearing Protection Ring - AEGIS_WTG_Test_Report-4-Dec-2007.pdf – and Appendix B
[23] Appendix C
[24] Appendix D

Action Items for the Electric Utility:

- Verify the integrity of the secondary neutral at the transformer for each residence.

- To separate the electrical phenomena produced exterior to the residences, all services in the areas investigated should be provided with Neutral isolation, accomplished by separate Primary and Secondary grounding at the transformer, with a secondary class surge arrester joining the two when surges are present, as sketched to the right. (source: Stray Voltages - Concerns, Analysis and Mitigation FINAL DRAFT - NEETRAC Project Number: 00-092 September 2001)



- If the isolation is insufficient to eliminate the EMI, then each transformer shall be replaced with an internally shielded design to further reduce EMI.

- Site G sits immediately below the 7200 V Primary. Whether out of ignorance, or other cause, this little detail presents an ongoing imminent danger that should be immediately rectified, as any form of accident that could cause the Primary to drop and make contact with the structure would immediately initiate a fire, and in case of personal contact, death.
- Site G should have the 7200 Volt Primary relocated beyond the perimeter of the house, at least 50 feet from any edge of the house, or where people traffic areas and children play areas exist. *

- Where the power line is located in roadways adjacent to the house, such as at Site F, relocate the line to allow enough space for a row of tree plantings between the primary and the residence. *

- If power lines are located adjacent to turbines, transpose the phase and ground wires 90 degrees per span, where single phase, or all wires, if three-phase, to provide a repeating change of orientation to induced EMI from turbine sources.

Action items for the Turbine Generator operators and their required interconnection:

- Measure Ground Current contribution for each Turbine to develop an expectable profile in Magnitude, Waveform, and Spectrum. Identify any significant deviations from the norm and troubleshoot and correct same.

- Employ monitoring equipment at each turbine, to identify if any uncontrolled ground current becomes excessive, and alert personnel to quickly correct the situation.

- Employ improved harmonic filtering or Active Power Factor correction at each turbine's exciter to eliminate the introduction of non-linear current into the soil.

- Identify sources of outgoing EMI and reduce or eliminate same.

- Employ wired real-time telemetering rather than wireless. This can be easily accomplished with Power Line Carrier since the turbines' power output does not go directly to any customer (or it should not), and is less subject to EMI effects than wireless.

Action items for the individuals:

- Remove all energized fixtures by the bedside. Namely all light fixtures, any alarm clocks, any radios etc. *They produce an impact regardless of whether the appliance is on or not, because the cord is still energized.*

- Replace all Fluorescent lighting of any form, where practical, with incandescent lighting. *An alternative is a Quartz-Halogen lamp, which has a dual glass envelope, is more efficient than a standard incandescent lamp, and is readily available.*

- Replace any structurally installed dimmer switches with conventional on/off switches.

- Employ an electrician to test for, and pursue correction of indoor wiring errors were found, per the protocol included at the end of Appendix B.

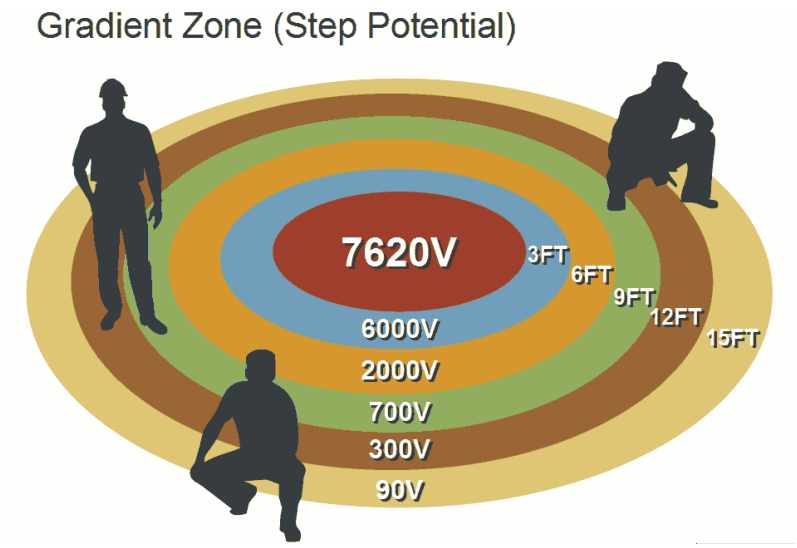
- Employ an electrician to verify the integrity of all accessible Neutral connections, including the one(s) behind the meter. *Repeat this verification on a ten year cycle, owing to an expected failure rate of once in 20 years, as highlighted within the referenced resource material.*

- Be continually vigilant for a condition known as bright-and-dim lights occurring simultaneously. *This is an indication of an impending Neutral failure (and a fire hazard), and the immediate action is to turn off / open the main breaker and call an electrician to investigate. This may occur at any time, even before the suggested neutral isolation at the transformer is accomplished.*

- If within your means consider planting trees between the aerial electric primary and the house. *A blockage of 50-70% should be sufficient to absorb and block all electric fields from reaching the house. The trees will attract the fields and shunt them to ground, without increasing ground current, as this is primarily an electrostatic effect.*

- Consider using small electronics' chargers that are labeled as accepting 90 -250 V as the input (as stated on individual labels on each charging device) only during daytime hours. *These are non-linear switch-mode power supplies that produce many harmonics, and having them plugged in only during daylight hours, removes their contribution from night time when most people sleep. Common transformers are labeled as only accepting 120 V. The difference is immediately obvious, even if the label cannot be read, by using an AM radio in close proximity to the device. A common transformer will be quiet, while a switch-mode power supply will blanket all frequencies within the reception range with electrical static (power frequency harmonics spanning into the MHz range)*

* Even without direct physical contact a downed power line can be fatal. Stepping across areas of more than a couple of hundred volts has the capability to arc right through shoes.



Instrumentation and Methodology

Alternating Current Electromagnetic Fields (EMF) - (a.k.a. Alternating Magnetic Fields)

A *Gigahertz HF3851A* alternating current (AC) magnetic field meter was used by the author to measure the magnetic flux density present at the survey properties. The instrument is a single axis "Gauss" meter, Gauss being a measure of Magnetic Field. Its usable frequency range is 5 Hz to 100 KHz. Its displayed unit of measurement is in nanoTesla (a European equivalent), 100 nT equals 1 milliGauss (mG). Its lower detection limit is 0.1 nT or 0.001 mG. Measurement was conducted at ground level for recording, and at waist level to get directionality of fields. It provides a single number as an aggregate level of all frequencies within its range. The purpose of the assessment was to ascertain what magnetic fields there were outdoors, their strength, direction, and character. As a point of reference the Earth's naturally occurring field is about 500 mG in most location on the planet.

A *Teslatronics Model 710* alternating current (AC) magnetic field meter was used by ET&T to measure the magnetic flux density present within the survey properties. The instrument is a tri-axial Gaussmeter. The frequency range for this instrument is 30 Hz to 2000 Hz. It provides a single number as an aggregate level of all frequencies within its range. The lower detection limit of the instrument is 0.1 mG. Measurements were conducted at about 4 feet above ground level. The purpose of the assessment was to ascertain exterior EMF or wiring influences and therefore do not reflect EMF levels present at interior point sources such as refrigerators, televisions or air condition units.

Alternating Electric Fields

The author used a plastic conductive bag, approximately 12" by 12" by 12" on a fiberglass pole whose capacitively-coupled voltage pickup was referenced to ground and fed to a PicoScope 2203 PC-driven Oscilloscope. When compared to the HF3851A Voltage sensing capability, a voltage of 500-600 mV on the conductive bag equated to about 200 V/m on the HF3851A. The free-form probe was more sensitive than the HF3851A, and was not limited by electronics' frequency limitations as in the HF3851A. The purpose of the assessment was to ascertain exterior contributions of multi-frequency emissions. When compared to indoor quantities, it was noted that housing structures provide a reduction factor of about 10. As a point of reference the Earth's field is about 100 Volts/meter between the ground surface and the ionosphere. This field changes dramatically with weather phenomena, primarily from changes in Relative Humidity (RH) where a high RH will cause low field detection.

PC-driven Oscilloscope

The author used a PicoScope 2203 to acquire waveform and spectral data from the HF3851A, the conductive bag on a fiberglass pole via capacitive coupling, or by direct lead contact with a source. The PicoScope 2203 is usable from 0 Hz (DC) to 5 MHz, with a sensitivity of less than 1 mV. The capacitive coupling method was also applied to measuring buss voltage within a breaker panel, where possible.

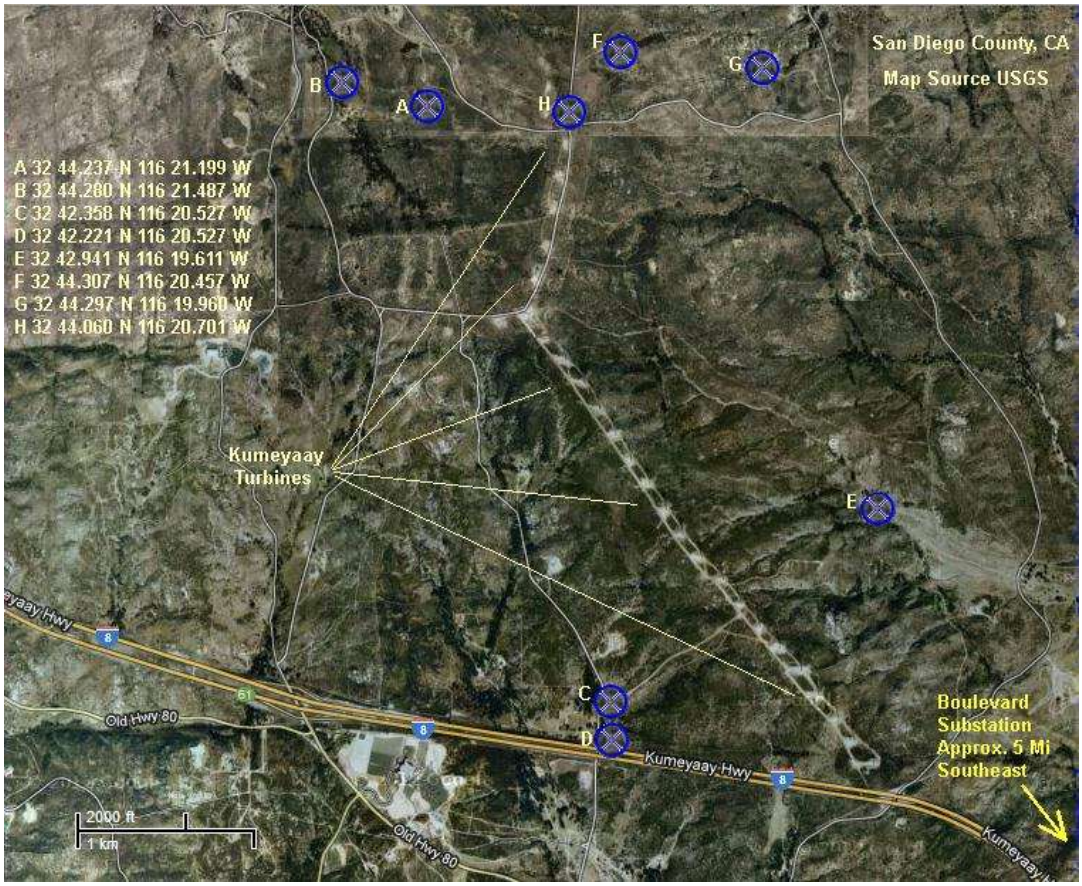
Radio Frequency (RF) and Microwave Survey

A *Wavecontrol SMP* portable electromagnetic field monitoring system with a *WPF8* probe was used by ET&T to obtain measurements of the power density (RF level) at the different survey locations. The *WPF8* probe has a frequency range from 100 kHz to 8 GHz. It provides a single number as an aggregate level of all frequencies within its range. The unit was used in a data logging mode and RF levels were recorded for at least 10 minutes. The measurement results are displayed and reported in Volts per meter (V/m). The lower detection limit of the instrument is 0.3 V/m. The instrument was calibrated according to manufacturer's specifications and instructions. The instrument was placed at 20 to 30' distance from the building on subject property. Measurements were recorded approximately 6 feet above the floor level. *Although levels may have been detected lower than 0.3 V/m, this instrument is not calibrated below 0.3 V/m, so ET&T decided to report data conservatively and note levels lower than 0.3 V/m as simply <0.3 V/m (less than 0.3 V/m) without giving the actual level.*

Measurement Locations

ID	Location	Latitude	Longitude	Site Description
A	Ginger Thompson	N 32° 44.237'	W 116° 21.199'	Residential property
B	Rowena Elliott	N 32° 44.280'	W 116° 21.487'	Residential property
C	Kumeyaay Wind Substation	N 32° 42.358'	W 116° 20.527'	Electrical substation on open property, next residential building approximately 500 yards away
D	Home owner name withheld by request	N 32° 42.221'	W 116° 20.527'	Residential property
E	David Elliott, Jr.	N 32° 42.941'	W 116° 19.611'	Residential property
F	Home owner name withheld by request	N 32° 44.307'	W 116° 20.457'	Residential property
G	Lance Conway	N 32° 44.297'	W 116° 19.960'	Residential property
H	By Turbine	N 32° 44.060'	W 116° 20.701'	Near operational turbine
I	SDG&E's Boulevard Substation	N 32° 39.709'	W 116° 16.424'	Electrical substation on open property, next residential building approximately 100 yards away
J	Jim Pelley	N 32° 45.131'	W 116° 00.133'	Residential property
K	Parke Ewing	N 32° 44.928'	W 116° 00.616'	Residential property
L	Open Desert	N 32° 45.060'	W 116° 00.580'	Open desert approximately 500 feet north from Ewing property border

Measurement Locations – North is at top



Magnetic Field and RF Survey Results

The following table summarizes the measurements results for the different type of measurements and evaluations performed during the survey.

ID	Location	M Field Inside	M Field Outside	RF Power Density	Comments
A	Ginger Thompson	< 0.1 mG	< 0.1 mG	< 0.3 V/m	
B	Rowena Elliott	< 0.1 mG	< 0.1 mG	< 0.3 V/m	
C	Kumeyaay Wind Substation	NA	10-16 mG	0.35 V/m	Background levels at about 150 feet distance
D	Home owner name withheld by request	0.1-0.2 mG	0.1-0.2 mG	0.3 V/m	
E	David Elliott, Jr.	< 0.1 mG	< 0.1 mG	0.4-0.6 V/m	
F	Home owner name withheld by request	0.1-0.4 mG	No Access	0.3 V/m	
G	Lance Conway	0.1-0.3 mG	0.2-0.3 mG	0.5-0.6 V/m	Distribution Primary over residence, E field 300-500 V/m outside and 30-50 V/m inside
H	By Turbine	NM	NM	NM	
I	SDG&E's Boulevard Substation	NA	0.9-6.1 mG	NM	Background levels at about 150 feet distance
J	Jim Pelley	< 0.1 mG	< 0.1 mG	0.6 V/m	
K	Parke Ewing	< 0.1 mG	< 0.1 mG	0.6 V/m	
L	Open Desert	NA	< 0.1 mG	NM	North of Ewing property

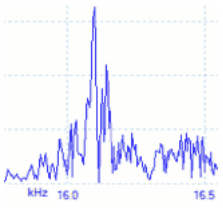
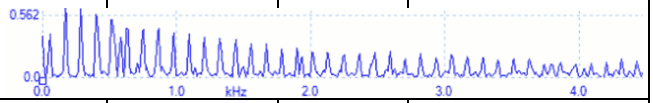
NA = Not applicable, NM = Not measured, 1 mG = 100 nT

· The **AC magnetic field** levels detected during the survey were very low and within a normal range of residential buildings in Southern California. Magnetic field levels are dependent on current flow. With increasing load conditions the field levels may increase in buildings were distribution lines are in proximity.

· The **RF levels** detected were low and well below levels commonly encountered in metropolitan areas in San Diego County. 0.3 V/m equals $0.02\mu W/cm^2$ 0.6 V/m equals $0.09\mu W/cm^2$

Waveform and Spectral Content Survey Results – *all measurements taken outdoors*

All pertinent graphics located in Appendix A

ID	Location	N-E V	Harmonics	M Field	Harmonics	E Field	Harmonics
A	Ginger Thompson ~ 3000' to nearest turbine, ~ 2 miles to Kumeyaay Sub, and ~ 7 miles to Boulevard Substation	~ 200 mV, Irregular with Power ON, ~ 200-300 mV 3-phase with Power OFF	3, 7, 9, 11, 13, 115, 17 with power OFF Note absence of 5th Harmonic	1-3 nT, 0.01-0.03 mG. 500-900 KHz EMI inducted into meter leads between gaussmeter and analyzer	3, 5, 7, 9 Persistent Background Electrical "noise" (EMI)	~ 30 V/m EMI, most pronounced at 16-16.5 KHz, and 3.5-4.8 MHz No Tree Buffer	3, 5, 7, 9 Persistent Background Electrical "noise" (EMI) 
B	Rowena Elliott ~ 4000' to nearest turbine, ~ 2 miles to Kumeyaay Sub, and ~ 7 miles to Boulevard Substation	~ 25 mV, many power frequency harmonics, and discrete EMI peaks with power off	3, a faint 5th, 7, 9, 11, 13, 15, and 17th Harmonics, but many other peaks, and pervasive EMI	1-2.5 nT / 0.01-0.025 mG. EMI, most pronounced at 3-4.5 MHz 	TNTC	Mostly obscured by Tree Buffer	EMI
C	Kumeyaay Wind Substation	NA	NA	~ 100 nT / 1 mG Vertical @ 60 Hz (from Substation equipment)	All very faint (2, 3, 5, 9), except the Fundamental (60 Hz) in Vertical field. Horizontal field (Ground Current) rich in Harmonics.	> ~ 200' from sources, ~ 10 V/m	NA
D	Home owner name withheld by request ~ 3000' to nearest turbine, ~ 1000' to Kumeyaay Sub	NA	NA	12 nT / 0.12 mG Vertical. 6 nT / 0.06 mG Horizontal	Both Vertical and Horizontal fields rich in harmonics and EMI, the one alternately obscuring the other.	~ 200' from sources, ~ 10 V/m, except where obscured by Tree Buffer	NA
E	David Elliott, Jr. ~ 3000' to nearest turbine, ~ 2 miles to Kumeyaay Sub, and ~ 7 miles to Boulevard Substation	350 mV power on, 250 mV power off	Odd Harmonics to 1 KHz. With power off, 60 Hz reduced, but harmonics increased size	EMI	EMI	3-8 mV depending on tree buffer	with much EMI between 60 Hz to 400 KHz

ID	Location	N-E V	Harmonics	M Field	Harmonics	E Field	Harmonics
F	Home owner name withheld by request ~ 2000' to nearest turbine, ~ 2 miles to Kumeyaay Sub, and ~ 7 miles to Boulevard Substation	NM	NM	~ 2 nT, 0.02 mG	3, 5, 7, 9, 11, EMI – most pronounced between 550 KHz and 1 MHz	~ 250 V/m	Discrete EMI peaks
G	Lance Conway ~ 4000' to nearest turbine, ~ 2 miles to Kumeyaay Sub, and ~ 7 miles to Boulevard Substation	NM	NM	20 nT, 0.2 mG	3, 5, 7. Distinct group of EMI at 27.5 KHz, 16 KHz	~ 700 V/m	NM
H	By Turbine	NA	NA	< 1 nT	Insufficient field strength, possibly due to being away from ground current route	< 3V/m	Pervasive EMI, most pronounced at 550-1200 Hz, 50, 55, and 60 KHz, 95 KHz, 115, 120, 130, and 140 KHz
I	SDG&E's Boulevard Substation	NA	NA	23 nT, 0.23 mG	3, 5, 9, Three-phase grounding current, EMI most pronounced between 500 KHz and 1 MHz	~ 30 V/m	NM
J	Jim Pelley Ocotillo area	370 mV	Wide-band EMI, most pronounced between 800 KHz to 2 MHz, and then low-level electrical noise to 3.5 MHz	15 nT, 0.15 mG – little difference between power on and power off	3, 5, 7, 9, 11– little difference between power on and power off	~ 70 V/m	Wide-band EMI 0.8 to 1.8 MHz, too many discrete peaks to be AM stations
K	Parke Ewing Ocotillo area	~ 1 V	3, 5, 7	~ 1 nT, 0.01 mG	Insufficient field strength to quantify	~ 15 V/m	NM
L	Open Desert Ocotillo area	NA	NA	1 nT, 0.01 mG There should have been	North to South orientation There should have been none	> 200' from sources, < 3 V/m	NM

				none			

N-E V = Neutral-Earth Voltage, **M** = Magnetic, 1 mG = 100 nT, **E** = Electric, **NM** = Not Measured, **NA** = Not Applicable, **TNTC** = Too Numerous To Count, **EMI** = Electromagnetic Interference - Electrical noise-compromised data

All harmonics are whole-number multiples of 60 Hz, so harmonics # 1, 2, and 3 would equate to the presence of 60 Hz (the Fundamental), 120 Hz, and 180 Hz. In most cases with irregular wave shapes only the ODD harmonics are present.

When the authors attempted Ground Current measurement North of the Ewing reference, in open desert, rods were stuck in the soil in an East-West direction, and nothing was detected. One rod was relocated so that the detection arrangement was North-South, and a tell-tale 60 Hz and harmonic signature emerged (*When placing metal rods in the soil such that they "straddle" any possible flow of current, their electric potential will be the same and no voltage will be detected. When placing metal rods in the soil such that they are parallel with the flow of current, they may divulge a 60 Hz and harmonic signature, because of the soil's electrical resistance between the rods. This is complicated by the ground current flowing through layers of soil whose depth below the surface is uncertain, and whose eventual route is also uncertain due to the non-homogeneity of the soil*.). Using the HF3851A Gaussmeter verified the presence and direction of the ground current, as it lined up with the flow corresponding to a North-South direction, and whose strength was about 1 nT, or about 0.01 mG. The reading should have been zero.

North is at top

Resources, not ordered

All documents listed are on the supplied disk, but addresses are valid as of time of retrieval, 12-2012

1) **Electrosmog in the environment** - Swiss Agency for the Environment, Forests and Landscape – SAEFL – June 2005 http://www.bafu.admin.ch/publikationen/publikation/00686/index.html?lang=en (PDF link on the page)
2) **Electric and Magnetic Fields Associated with the Use of Electric Power** – Prepared by the National Institute of Environmental Health Sciences - National Institutes of Health, sponsored by the NIEHS / DOE **EMF RAPID** Program – June 2002 http://www.niehs.nih.gov/health/assets/docs_p_z/results_of_emf_research_emf_questions_answers_booklet.pdf
3) **Why Ground Currents** – 2001 Dahlberg 2001 http://www.mikeholt.com/mojonewsarchive/SV-HTML/HTML/WhyGroundCurrents~20020921.htm
4) **Ground Currents- An important factor in electromagnetic exposure** – 2000 Duane A. Dahlberg, Ph.D. Consultant, The Electromagnetics Research Foundation, Inc. 1317 6th Ave. N. Moorhead, MN 56560 (218) 233-8816 http://www.mikeholt.com/news/archive/html/17/Ground_Currents_09-18-2002.htm
5) **Electrosmog - a Phantom Risk, an Insurance Perspective** – 1996 Swiss Reinsurance Company http://people.ee.ethz.ch/~serec/presentations_21_Dec_2009/08-STAUB_SwissRE-Insurance_Radar.pdf
6) **Stray Voltage Solutions Guide for Electrical Contractors -** Hydro One Networks Inc. – 11-2007 http://www.hydroone.com/MyBusiness/MyFarm/Documents/SVSolutionsGuideforElectrical_Contractors.pdf
7) **PA Bulletin, Doc. No 1635, 3-2010 Neutral Rulemaking Withdrawal** – *regarding inspection requirements for customer neutrals* - http://www.pabulletin.com/secure/data/vol40/40-13/553.html
8) **DQE-Neutral_Conn_IM_Standards**, Duquesne Light Company – *comments to PA PUC in the above matter* - http://www.puc.state.pa.us/electric/pdf/DQE-Neutral_Conn_IM_Standards.pdf
9) **Harmonics in your electrical system -** *What they are, how they can be harmful, and what to do about them* – Eaton Corporation, undated - http://www.newark.com/pdfs/techarticles/eaton/Eaton_Technical_Articles/UPS_Training/Powerware_Training/HarmonicsInYourElecSystem.pdf
10) **Hazards of Harmonics and Neutral Overload** - *a Schneider Electric White Paper*, 2011 - http://www.apcmedia.com/salestools/SADE-5TNQZ5_R1_EN.pdf
11) **Adverse health effects of exposure to power frequency electric and magnetic fields (EMFs) –** Dennis L. Henshaw; H H Wills Physics Laboratory Royal Fort, Tyndall Avenue, Bristol, UK BS8 1TL 5 – 2010 - http://www.foodsmatter.com/es/electricity_dirty_el_lighting/articles/powerlines_background_research_henshaw_11.pdf
12) **Historical Evidence that Residential Electrification Caused the Emergence of the Childhood Leukemia Peak** - S. Milham, E. M. Ossiander – 2001 - http://d1fj3024k72gdx.cloudfront.net/historical_leukemia.pdf
13) **Evidence that Electromagnetic fields from high voltage powerlines and in buildings, are hazardous to human health, especially to young children** - Dr. Neil Cherry – 2001 www.esdjournal.com/techpapr/elfhealth.pdf
14) **Evidence that Electromagnetic Radiation is Genotoxic: The implications for the epidemiology of cancer and cardiac, neurological and reproductive effects** - Dr. Neil Cherry – 2000 - http://www.neilcherry.com/documents/90_m2_EMR_Evidence_That_EMR-EMF_is_genotoxic.pdf

15) **Aegis - Preventing Generator Shaft Current Damage** - William Oh - Electro Static Technology, 9-2006 - http://est-aegis.com/TechPaper.pdf

16) **Building Biology guidelines** – 2008, latest release www.maes.de (bottom of page) - *These are an alternative to "standard" guidelines, in that they are evidence-based, and they stratify exposure with levels of Concern based on magnitude of the component measured. Rather than stating that exposure below a certain level is "safe," the authors' experience indicated that reduction for exposure levels from the Extreme Concern to No or Slight Concern levels rendered relief, sometimes immediate, to those affected. While they are not intended to cripple economies, proponents note that the recommendations are intended for sleeping areas, a place and time when individuals slow down to sleep, rest, and recuperate, such that they can be better able to tolerate the daily stresses of waking hours.*

17) **THE BIOINITIATIVE REPORT 2012** - A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Fields (ELF and RF) http://www.bioinitiative.org/

18) **Leukemia following Occupational Exposure to 60-Hz Electric and Magnetic Fields among Ontario Electric Utility Workers Anthony B. Miller et.at. January 1996 -** Evaluation of the combined effect of electric and magnetic fields for leukemia showed significant elevations of risk for high exposure to both, with a **dose-response relation for increasing exposure to electric fields** and an inconsistent effect for magnetic fields. http://www.ncbi.nlm.nih.gov/pubmed/8678046

19) **Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations** – Khurana et.al. – International Journal of occupational Environmental Health – 2010; 16:263-267 – http://www.brain-surgery.us/Khurana_et_al_IJOEH-Base_Station_RV.pdf

20) **Cell Phones and brain tumors: a review including the long-term epidemiologic data** – Khurana et.al. – Surgical Neurology 72 (2009) 205-215 online at www.sciencedirect.com or http://www.mmk.be/afbeeldingen/File/meta_GSM_hersenen.pdf

21) **Gamesa Wind Turbine Generator Catalog** - http://www.gamesacorp.com/recursos/doc/productos-servicios/aerogeneradores/catalogo-g9x-20-mw-eng.pdf

22) **Late Lessons From Early Warnings - The Precautionary Principle 1896–2000** – European Environment Agency - ISBN 92-9167-323-4 © EEA, Copenhagen, 2001

23) CPUC Action Regarding EMFs - http://www.cpuc.ca.gov/PUC/energy/Environment/ElectroMagnetic+Fields/action.htm

Books

24) **Dirty Electricity** – Sam Milham, MD, PHD - Publisher: iUniverse, 2010 ISBN 978-1-4502-3821-2

25) **Radio-Frequency and ELF Electromagnetic Energies – A Handbook For Health Professionals** - R. Timothy Hitchcock, Robert M Patterson - Publisher: Van Nostrand Reinhold, 1995, ISBN 0-442-00945-3

26) **ENERGY MEDICINE: The Scientific Basis** - James L. Oschman, Candace Pert - Publisher: Churchill Livingstone, Inc., - 2000, ISBN: 0-443-06261-7

27) **CROSS CURRENTS, The Perils of Electropollution, The Promise of Electromedicine** - Robert O. Becker M.D., - Publisher: James P. Tarcher Inc. 1990, ISBN 0-87477-609-0

Limited Glossary

In any discussion of energy, frequencies, and Electromagnetic Fields (EMF) there is a need for **Scientific Notation**, to make sense of very large or very small numbers.

The most common multipliers used are:

Pico (p) = x0.000,000,000,001 (or $x10^{-12}$) Nano (n) = x0.000,000,001 (or $x10^{-9}$)

Micro (u) = x0.000,001 (or $x10^{-6}$) Milli (m) = x0.001

Kilo (K) = x1000 (or $x10^{3}$) Mega (M) = x1000,000 (or $x10^{6}$)

Giga (G) = x1000,000,000 (or $x10^{9}$)

Some of the more common foundational units are:

Cycles per second (cps) or Hertz (Hz),

Gauss (G) a unit of magnetic field,

Tesla (T) – the European unit of magnetic field, 100 nT = 1 mG

Volts (V) – a unit representing electric potential, 1 V = 1000 mV

Amperes or Amps (A) – a unit of current flow. 1 A = 1000 mA

Radio Frequency is generally considered to begin around 30,000,000 Hertz or 30 MHz, although the AM Broadcast bands in the 540 KHz to 1.6 MHz are also designated as "Radio"

Units of **Magnetic field** are generally expressed in milliGauss (mG) or nanoTesla (nT).

Units of **Electric field** are generally expressed in Volts / meter. As an example, for a 7200 V electric primary suspended 30 feet in the air (a typical height), the electric field directly below would be Volts divided by the height. Since 30 feet (30') is approximately 10 meters (10 m), the relationship becomes 7200 V / 10 m, or 720 V/m or about 700 V/m.

When an electrically conductive structure (which includes humans) is exposed to a field of any kind with **relative motion** to the structure, what occurs is **Transformer Action / Action at a distance / Induction**, which causes internal and external currents and voltages to the structure. When the source is not physically moving but the components (voltage, current) are changing, and their reach extends onto a conductive structure, the relative motion criteria is satisfied. Although the discussion is centered on power lines, inside an automobile similar events occur, in that the alternator produces an Alternating (changing with respect to time) Magnetic field, in the process of generating power. This magnetic field in most cases extends into the passenger compartment.

Harmonics are produced by non-smooth electrical phenomena, some of which are repetitive and described within this document. **Transient** phenomena, such as lightning, also produce a wide-band presence of harmonics, even though they are not repetitive. The firing of spark plugs produces the same effect on a smaller scale. Turning a light switch on or off, produces the same effect on a much smaller scale.

Discussion of EMF also inevitably involves **Wavelength**. Since EMF travel at the speed of light or about 186,000 miles/second, the wavelength is 186,000/frequency. For 60 Hz it is about 3100 mi. The term **Microwaves** then pertains to frequencies whose wavelength is small, such as faster than 1 GHz. A microwave oven for instance, using about 2.45 GHz would have a wavelength of about 4 inches.

Author Bios in Brief

Sal La Duca, Principal - Environmental Assay Inc. / Indoor Environmental Consultant / www.emfrelief.com

Sal is an Environmental Consultant specializing in the built environment, with over 30 years' experience in instrumentation and controls. After receiving two years training in the physical sciences, Sal performed as a Nuclear Reactor Operator / Reactor Technician (Instrumentation and Control Technician - Nuclear) on the USS Mississippi, CGN40, and participated in initial construction, initial criticality, Commissioning (1978), and shakedown operations. During this time he also acquired a First Class FCC License with Radar Endorsement. He was then offered employment by Jersey Central Power and Light to help build a Radiological Survey instrument repair facility at the Oyster Creek Nuclear Plant in Forked River, NJ. After having done so, and trained sufficient employees to man the facility, he migrated to the Communications department, where he performed installation, calibration, and repairs of various generations of remote-control supervisory equipment for power system control, as well as work on fixed and mobile Radio Frequency equipment. After three years of this work he migrated to the Dispatch Center and performed as a Power System Load Dispatcher for six years, performing all operations of system control, maintenance, and restoration. He then had an opportunity to return to the Communications department where he performed as an Instrumentation and Control Technician.

In 1994 Sal incorporated and began offering Electromagnetic Field services. In 1999 he sought and acquired certification as a Building Biology Environmental Consultant with the Institute of Building Biology and Ecology, Clearwater, FL, and expanded service offerings to include Indoor Air Quality. In 2003 he sought and acquired Indoor Environmental Consultant status with the Indoor Air Quality Association. He holds a Bachelor of Science from the University of Phoenix, AZ.

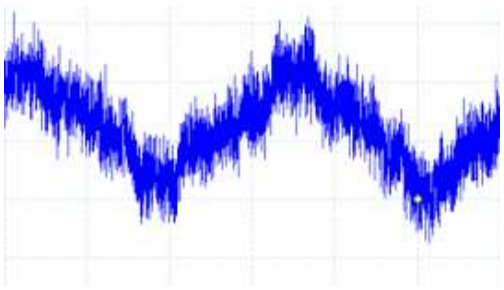
Peter Sierck, Principal - Environmental Testing and Technology / Industrial Hygienist, REA / www.etandt.com

Peter is an Industrial Hygienist with over 25 years of experience performing professional low and high frequency electromagnetic field measurements, designing EMF and RF mitigation plans and developing management plans. His technical experience includes alternating current (AC) electric and magnetic fields, direct current (DC) electric and magnetic fields, high radio frequency and microwave radiation surveys. He has conducted surveys for commercial, institutional and residential buildings, performing RF measurements for cell sites, computer interference investigations, performing EMF studies for developers and providing EMF management plans for numerous school districts and acted as a liaison with utility companies on magnetic field reduction methods.

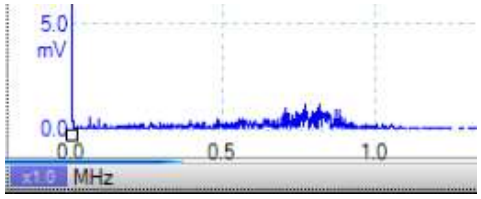
Peter Sierck is a Registered Environmental Assessor (REA) with the State of California, a Certified Indoor Environmental Consultant (CIEC) with the American Council of Accredited certifications (ACAC) and a charter member of the National Electromagnetic Field Testing Association (NEFTA) founded in 1991. Peter started his environmental education in Germany. Mr. Sierck has studied industrial hygiene, environmental testing methods and engineering controls at the Engineering School in Hamburg, University of California San Diego, University of California Berkeley, and the MidAtlantic Environmental Hygiene Resource Center (MEHRC) in Philadelphia. Mr. Sierck was designated by the Honorable Judge Lawrence Sterling of the San Diego Superior Court as an Expert Witness in March of 1999 in accordance with the California Evidence Code Section 720.

Appendix A: Waveforms and Spectra

Site A: Ginger Thompson's

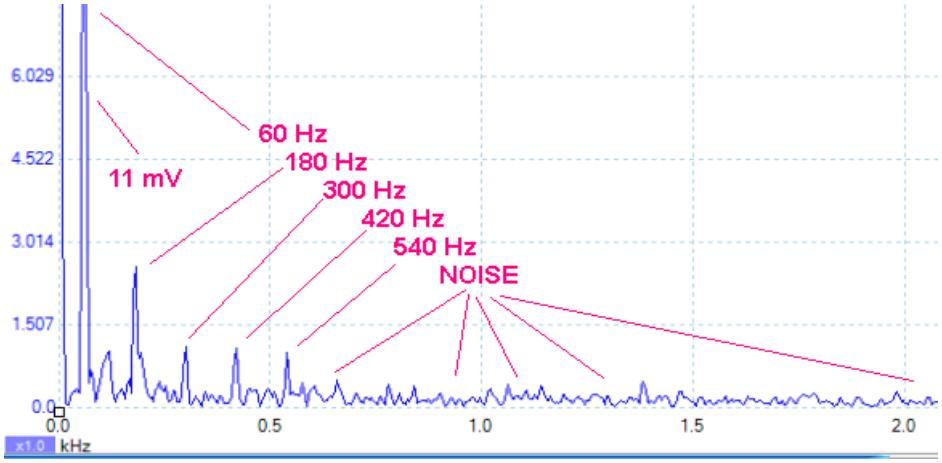


*60 Hz Ground/Grounding Current + EMI induced in Gaussmeter (**M-field**) test leads*

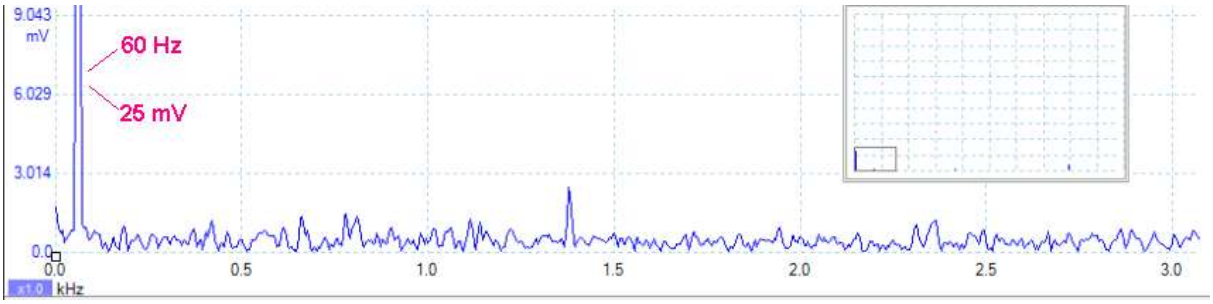


EMI Spectrum

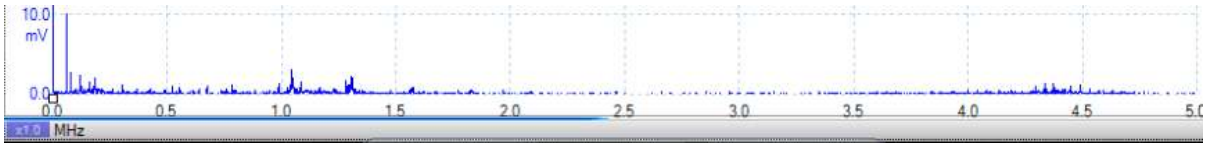
EMI close-up



***M-field** Ground / Grounding Current and Electrical Noise – Note 3rd, 5th, 7th, and 9th Harmonics*



***E-Field** from 7200 V Primary, Minimal Current & No Harmonics, but lots of Electrical Noise*

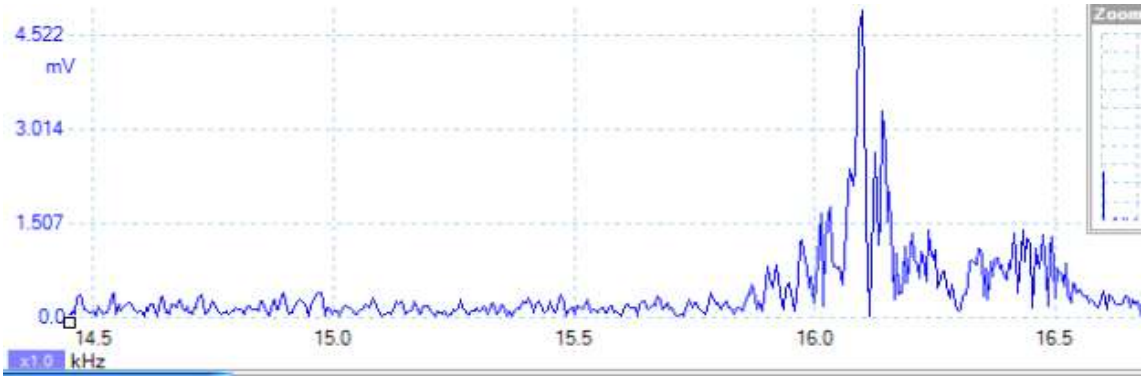


*Wide-band EMI induced in **E-field** pickup*

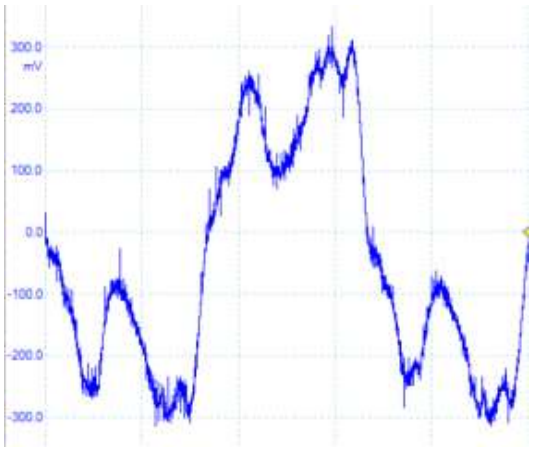
Close-up of right side of above capture

Progressive EMI (close-up of left corner of first graph above)

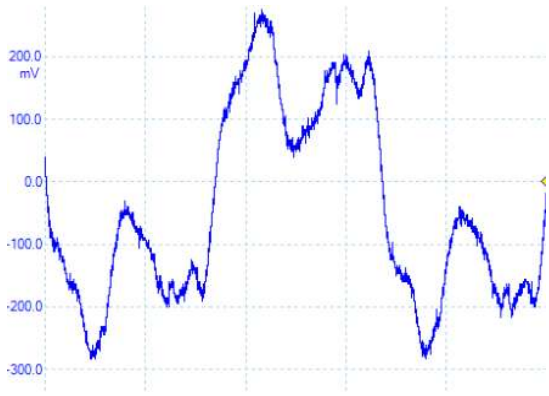
Progressive EMI a few seconds later



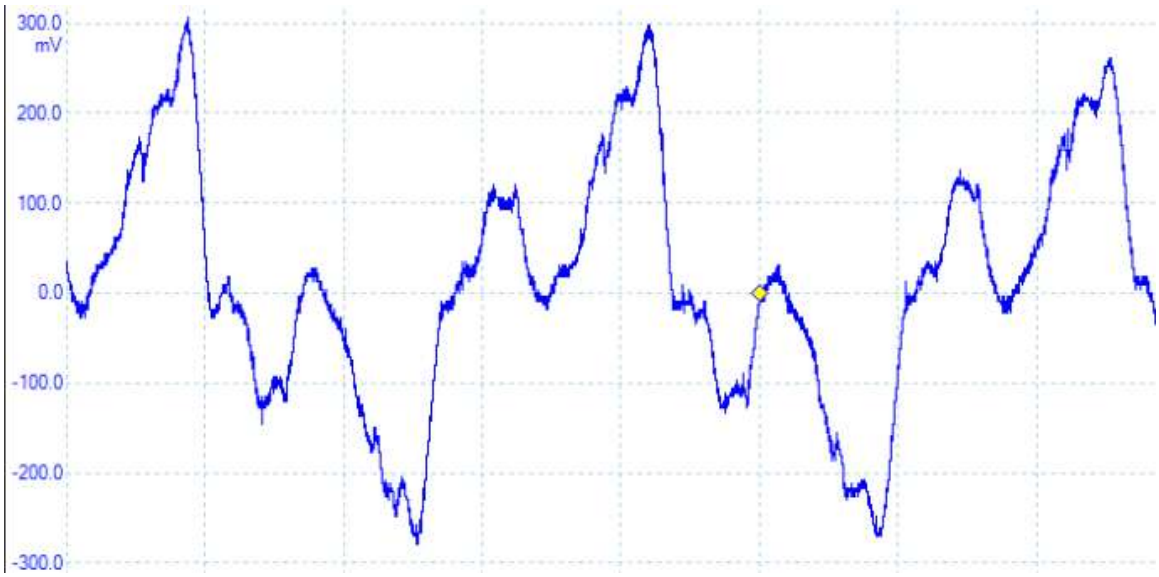
Progressive EMI a few more seconds later



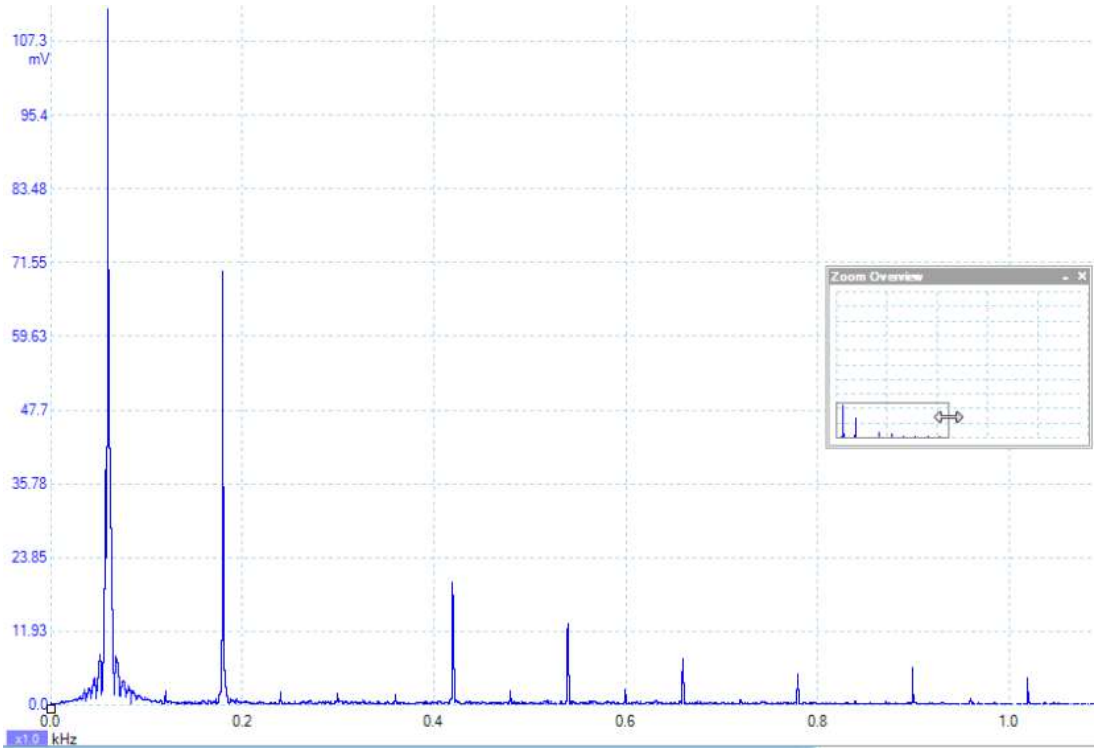
Neutral-Earth Voltage *- Power ON*



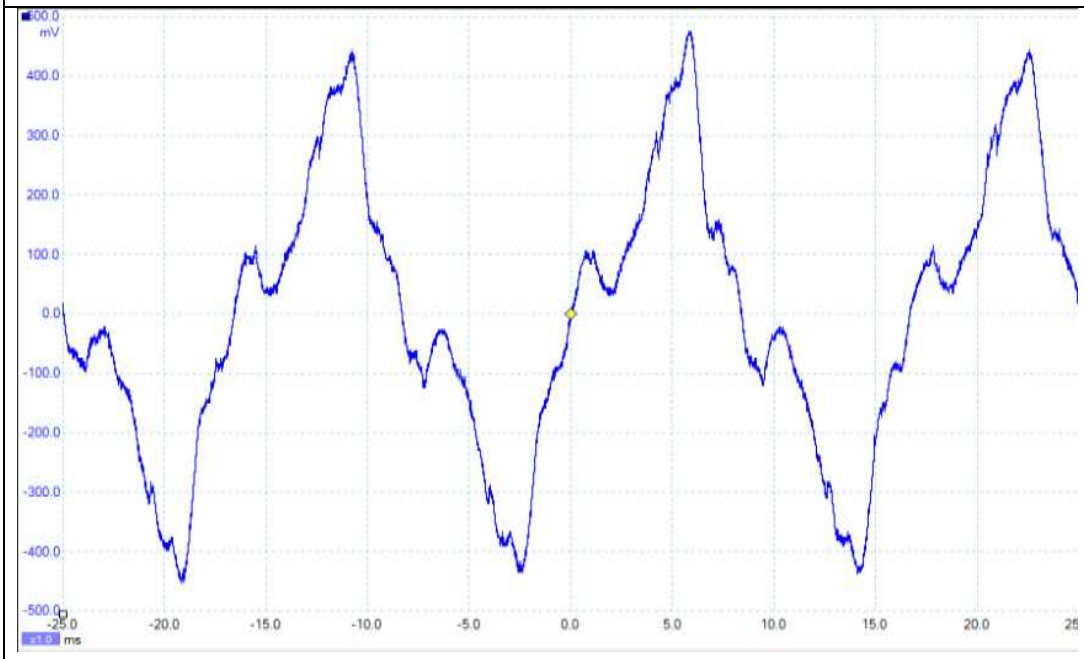
Neutral-Earth Voltage *- Power ON*



Neutral-Earth Voltage *– <u>Power OFF</u> –* ***Note this is 3-phase power***

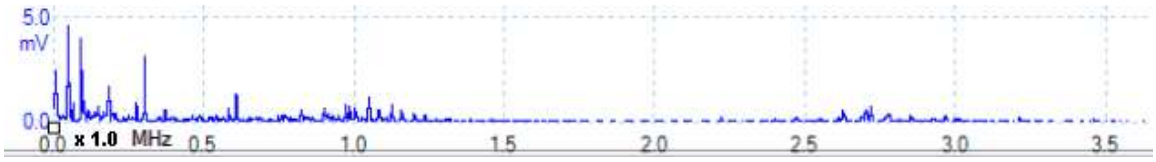


Neutral-Earth Voltage *– <u>Power OFF</u> – Note 3rd, 7th, 9th, 11th, 13th, 15th, and 17th Harmonics, and note the presence of new harmonics and absence of the 5th harmonic (300 Hz) which was present with power on*



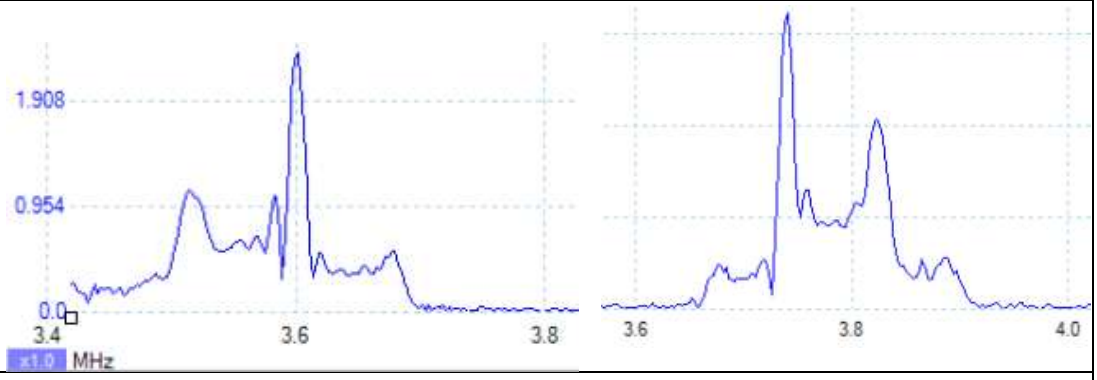
Neutral-Earth Voltage *– <u>Power OFF</u> – Note instantaneous size changes from previous capture*

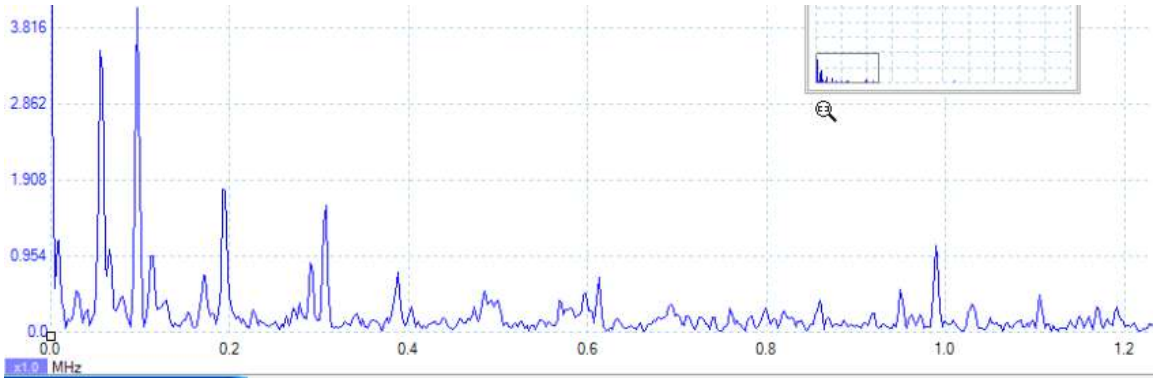
Site B: Rowena Elliott's



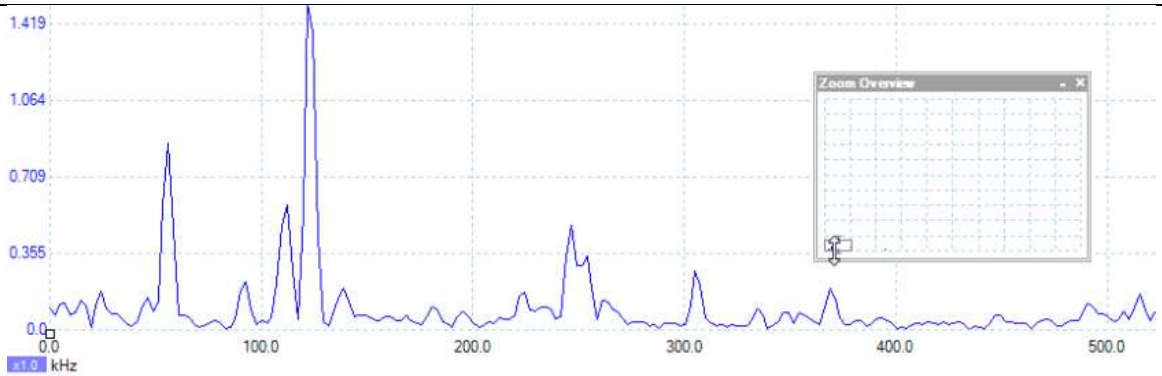
EMI induced in Gaussmeter (M-field) test leads

Erratic EMI bursts occurring between about 3 MHz and 4.5 MHz

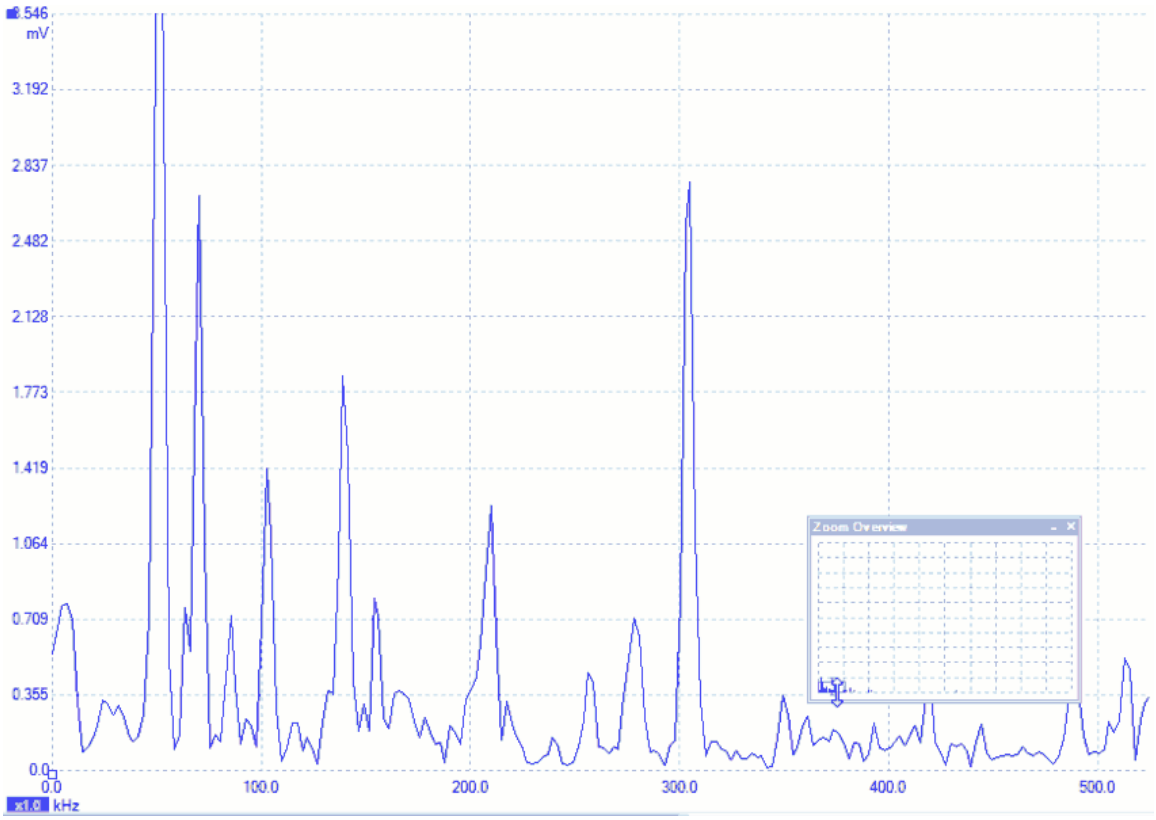




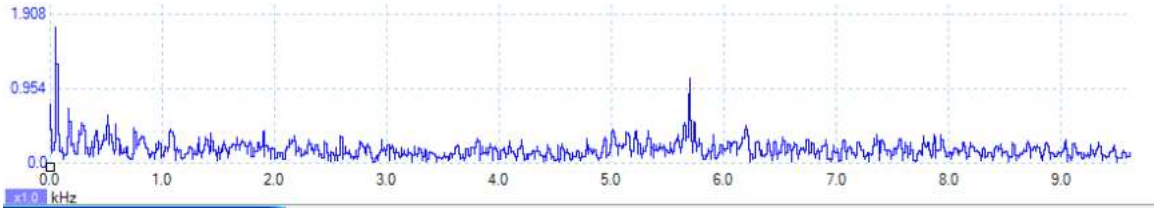
Ongoing EMI onto Gaussmeter leads, all frequencies above 0.1MHz (100 KHz) induced into leads



EMI onto Gaussmeter leads (above 100 on this scale), Close-up

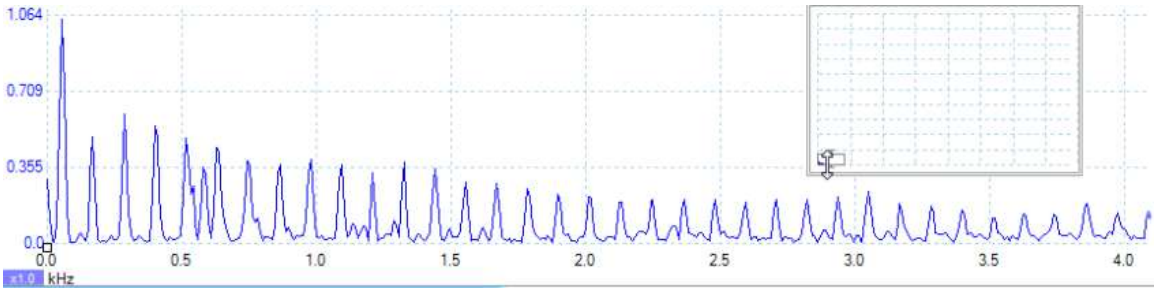


EMI onto Gaussmeter leads, Close-up, note instantaneous quantum leaps in intensity



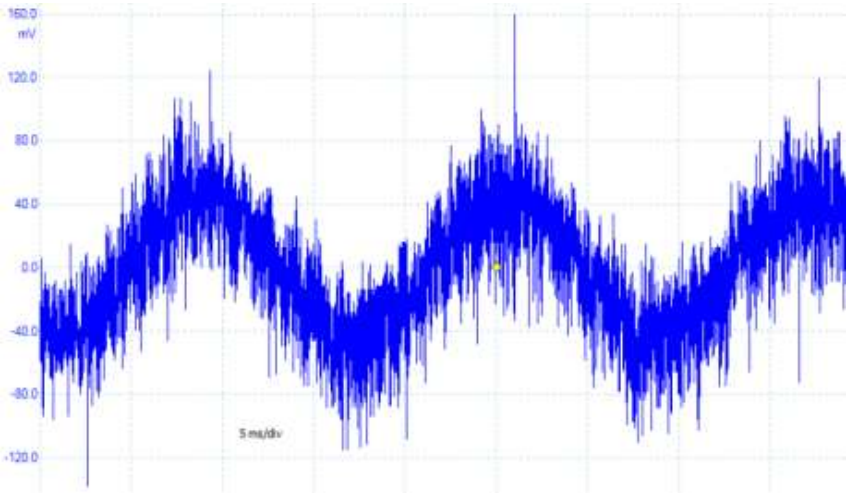
Pervasive Wide-band EMI

Power Frequency Harmonics, note reduced Fundamental (60 Hz)

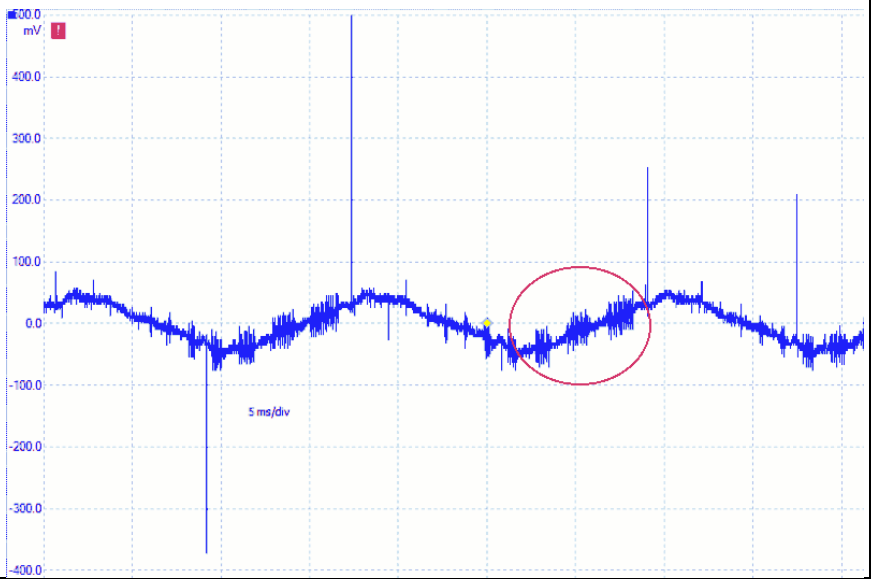


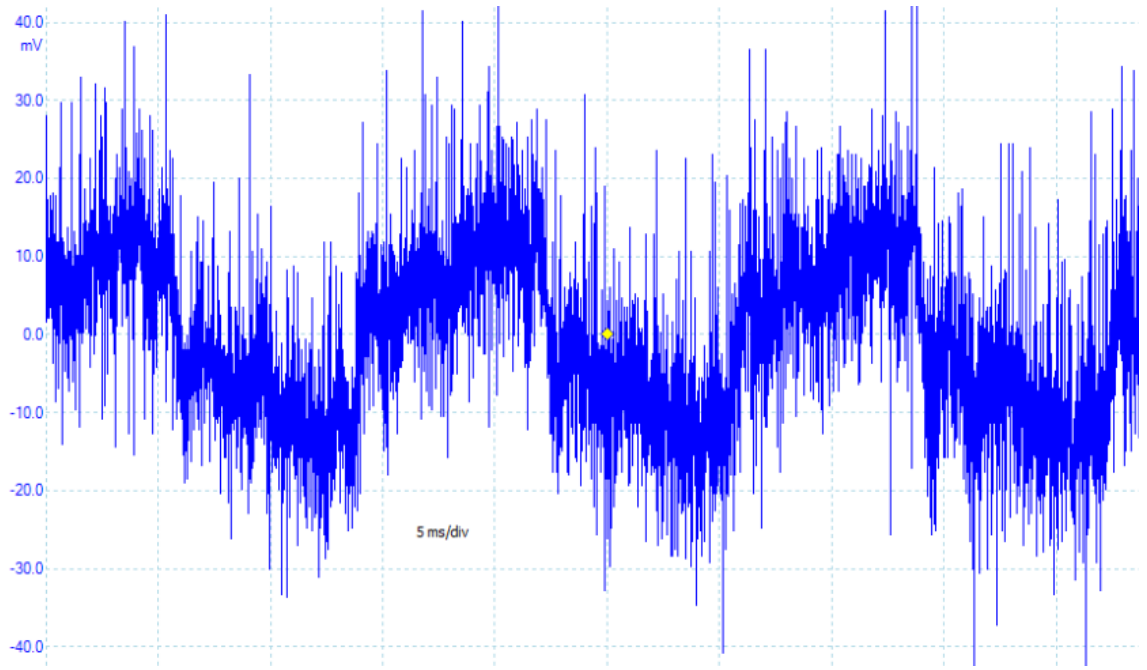
Power Frequency Harmonics, Close-up, 60 Hz prominent (first spike)

Electric Field *pickup from power line and EMI*

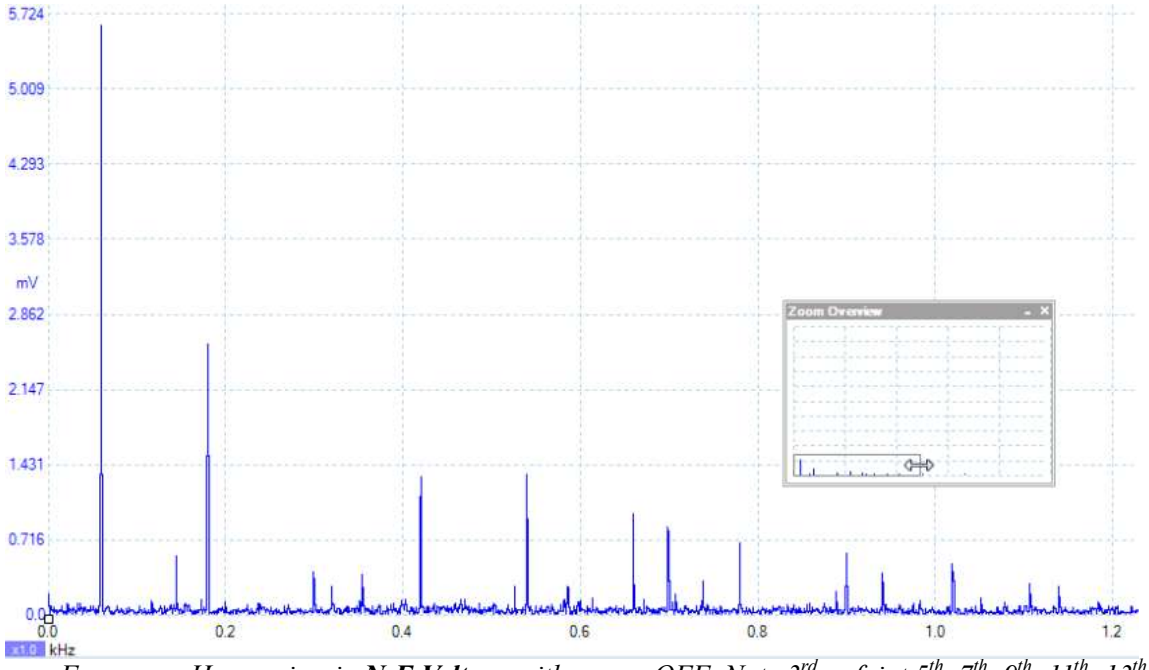


Neutral to Earth Voltage*, Power ON. Note highlighted area with higher frequency bursts riding on top of the 60 Hz wave, their frequency being some 100 times faster, or about 6000 Hz. This contribution, to devices that are designed to use only 60 Hz, can produce equipment heating that it is not designed for, and may accelerate equipment failure.*



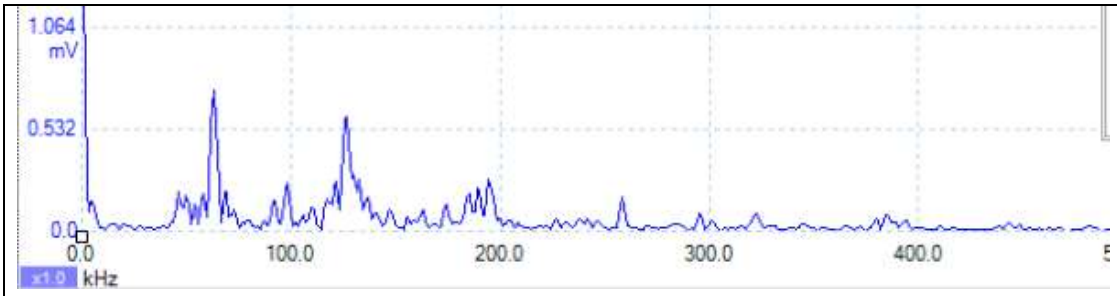


***Neutral to Earth Voltage**, Power ON, Close-up, note the faint resemblance to 60 Hz*

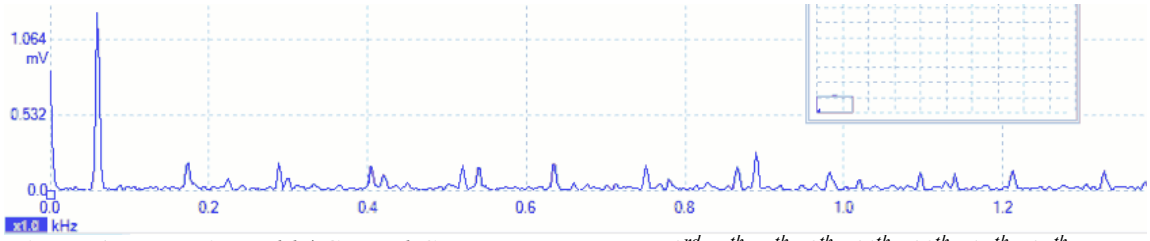


*Power Frequency Harmonics, in **N-E Voltage** <u>with power OFF</u>. Note 3rd, a faint 5th, 7th, 9th, 11th, 13th, 15th, and 17th Harmonics, but also note that other peaks are not harmonics and constitute electrical noise, or Electromagnetic Interference (EMI)*

Site C: Kumeyaay Wind Substation



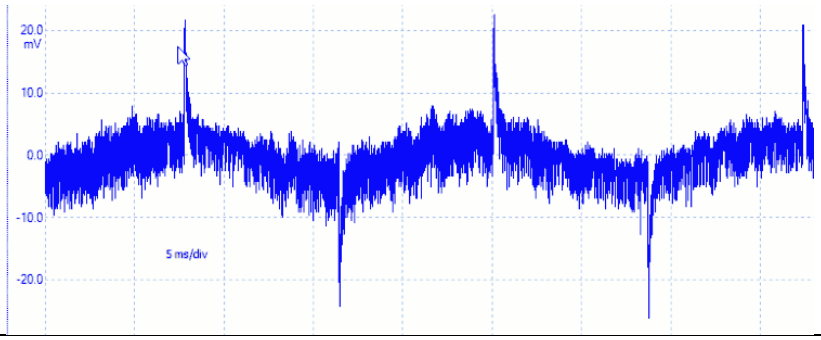
Vertical Magnetic *Field to 100 KHz, and EMI induced onto meter leads beyond that.*

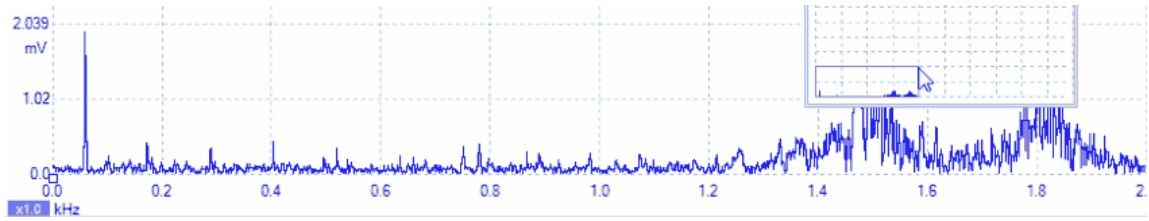


Horizontal Magnetic *Field / Ground Current. Harmonics: 3rd, 5th, 7th, 9th, 11th, 13th, 15th, 17th, etc.*

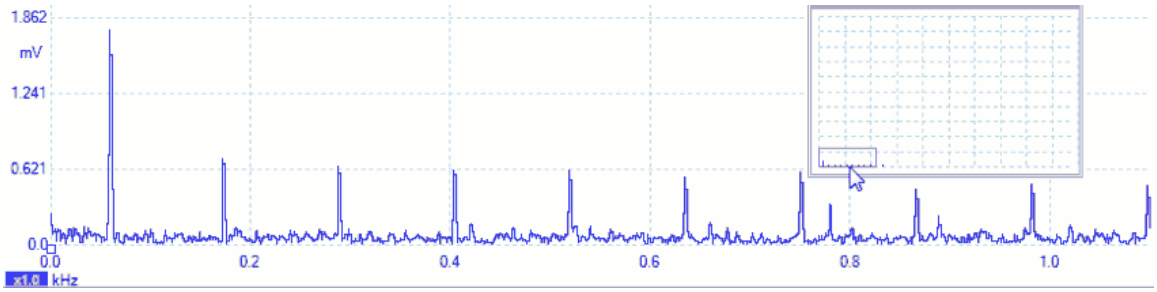
Site D: Home owner name withheld by request

Vertical Magnetic field. Major Positive and Negative spikes characteristic of non-linear loads, such as plasma lighting (fluorescent, high pressure sodium, etc.)

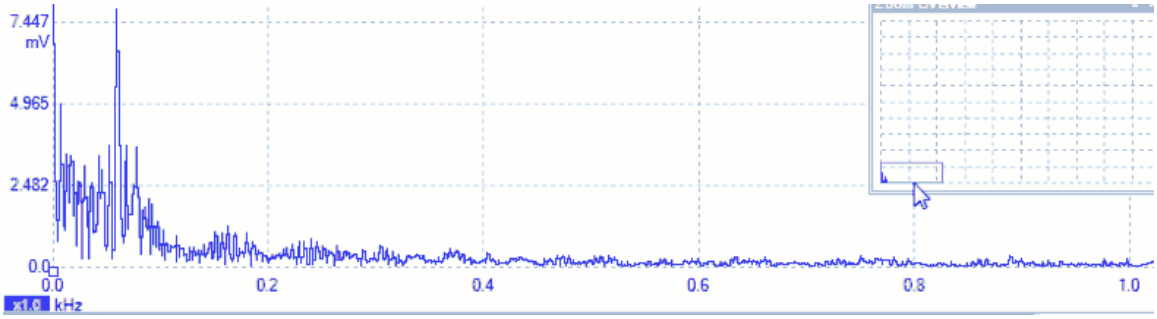




Vertical Magnetic *Field. Note 60 Fundamental (first major spike), and generous EMI with prominent peaks at about 1.5 and 1.8 KHz*

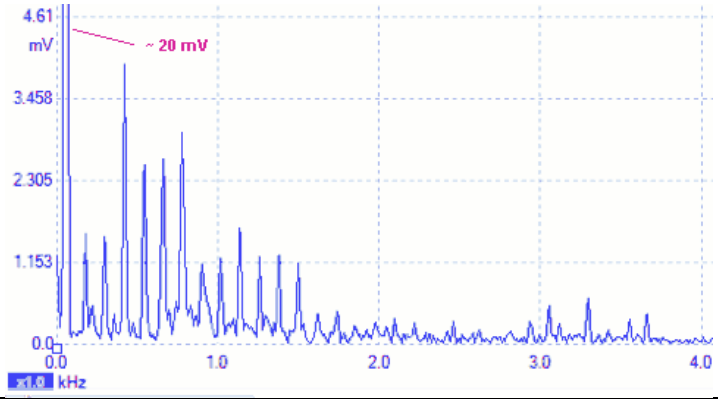


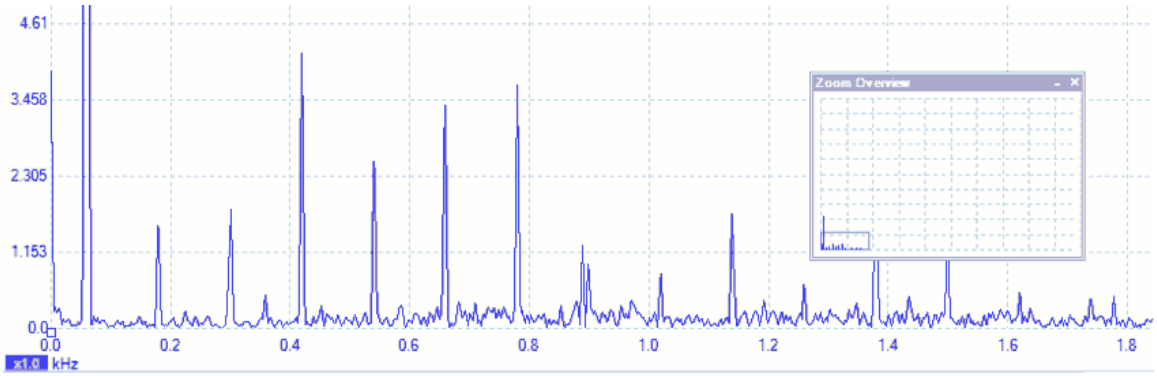
Vertical Magnetic *Field. Note that 60 Hz and Harmonics were intermittent with obscuring EMI.*



Vertical Magnetic *Field EMI, intermittent with 60 Hz and Harmonics*

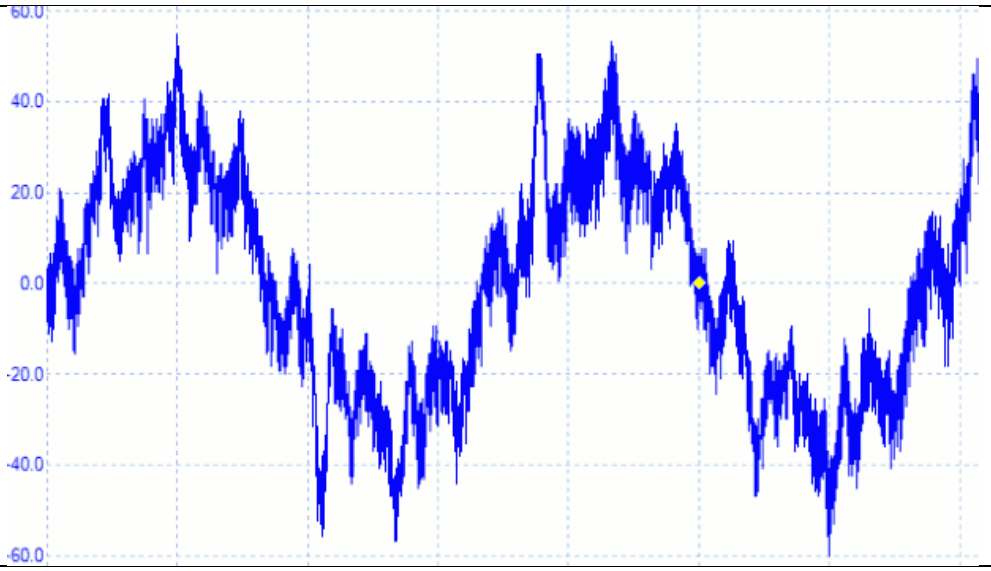
Horizontal Magnetic *Field, several power frequency harmonics among the pervasive electrical "noise" (EMI)*





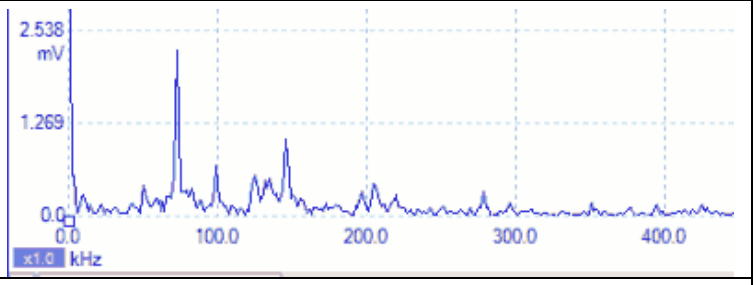
Horizontal Magnetic *Field with Fundamental(60 Hz) and Harmonics, Close-up*

Vertical Magnetic Field

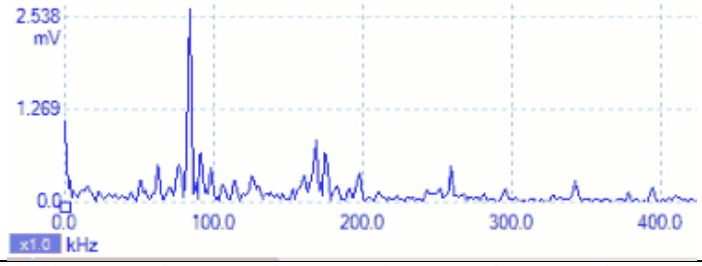


Site E: David Elliott, Jr.'s

Electric Field *EMI, its character varied slightly in frequency, but was sputtering continuously between 60 Hz and 400 KHz*

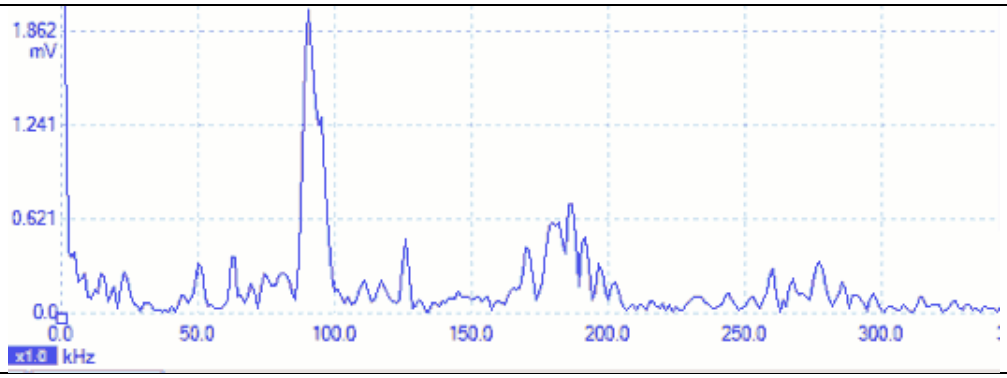


The same EMI a few seconds later

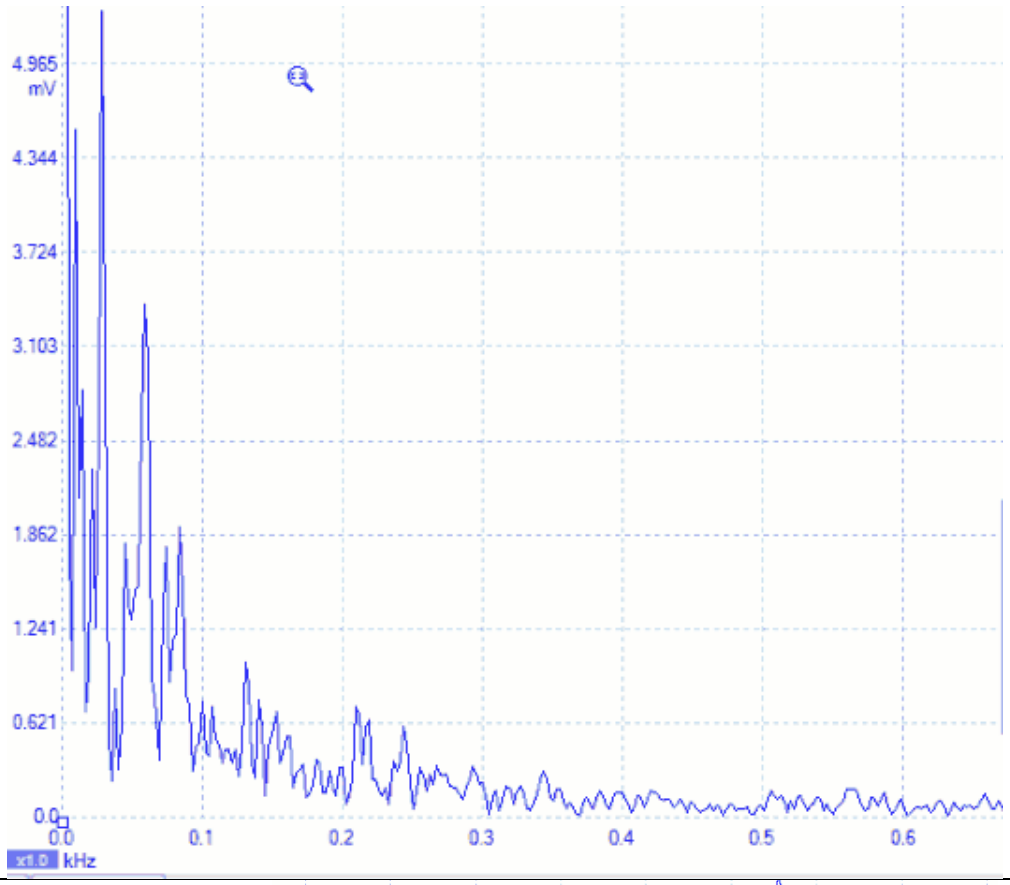


A close-up

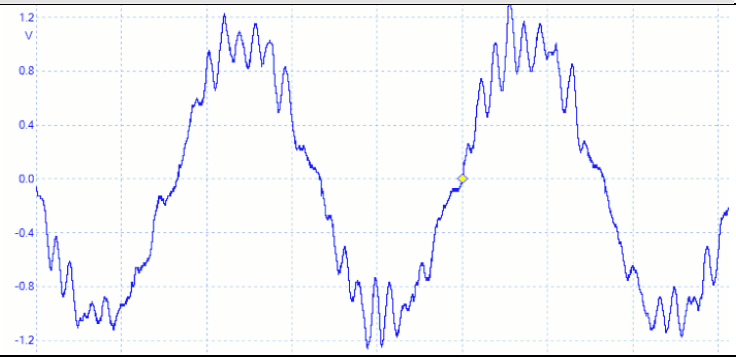
The same EMI a few seconds later



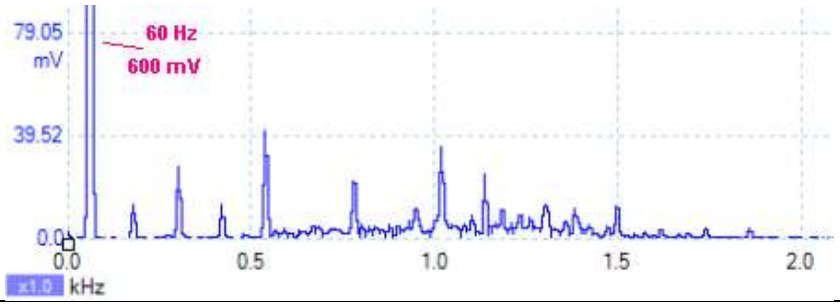
Major equipment starting transient, around midday

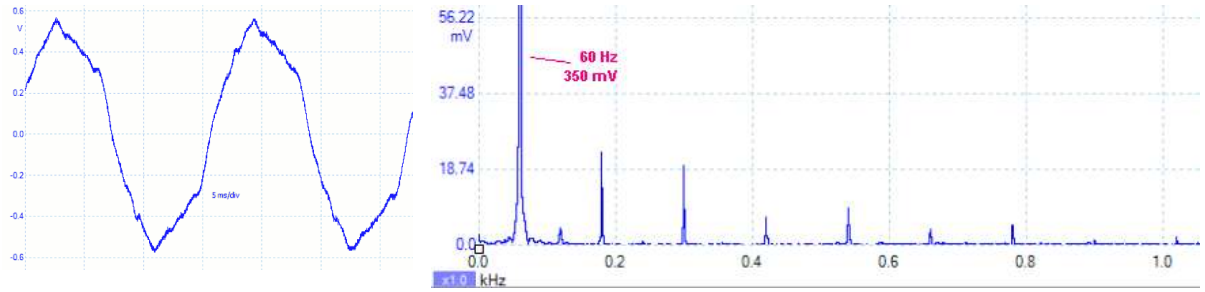


Sampling of an energized lead voltage *at the electrical panel. The vertical scale should be multiplied by 140, as the peak in either direction is 170 Volts, for the standard 120 Volts residential service. Under normal loads the Voltage should Not vary as significantly as shown, and suspect this to be external.*

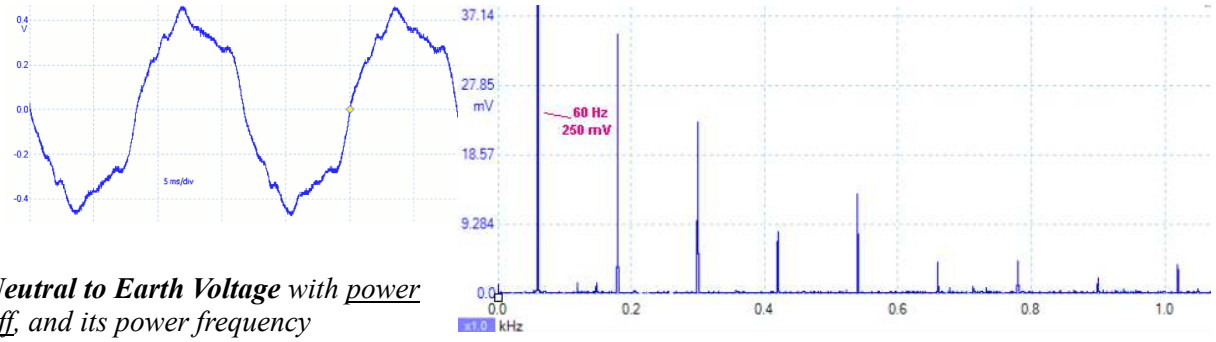


*The spectrum of the **energized lead voltage** at the panel. Power Frequency Harmonics and background EMI.*





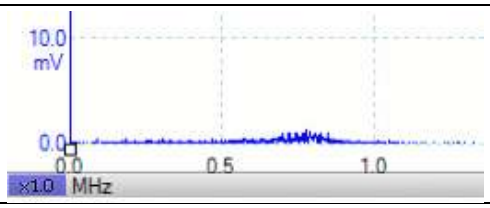
***Neutral to Earth Voltage** with power on, and its power line harmonics*



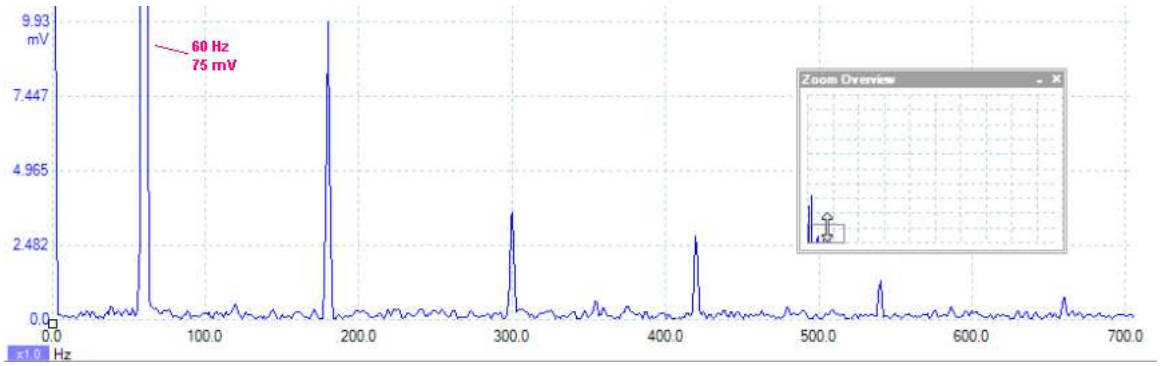
***Neutral to Earth Voltage** with <u>power off</u>, and its power frequency harmonics. Note that although the 60 Hz is reduced, the Harmonics increased in size.*

Site F: Home owner name withheld by request

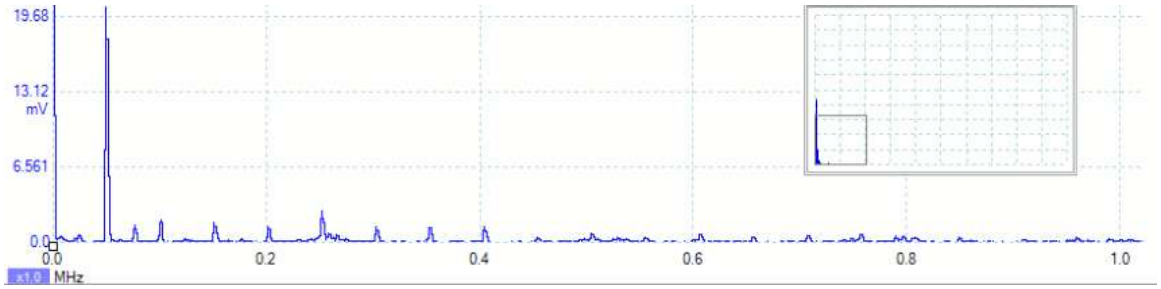
***Vertical Magnetic Field** pickup with EMI induction into test leads between about 500 KHz and 1 MHz*



EMI close-up

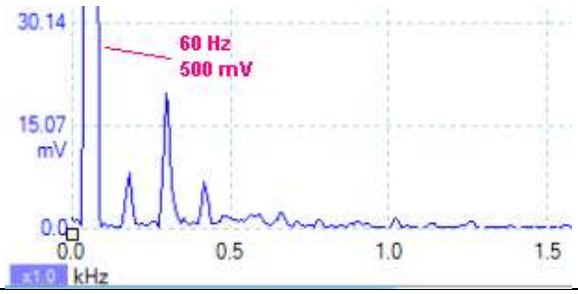


Horizontal Magnetic *field, power frequency harmonics and electrical "noise"*

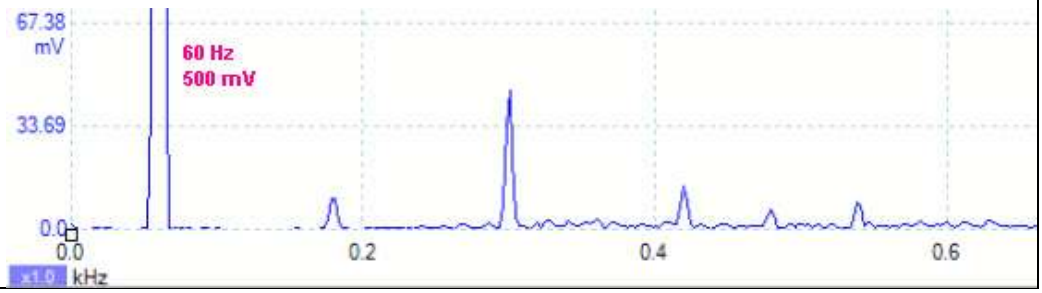


Electric field *pickup. Note these are not power frequency harmonics, but EMI*

Electric field *pickup with some power frequency harmonics, intermittent with the EMI – Note how the same harmonic size relationships are maintained when a sample is taken off a bus voltage in the panel (below), because in the transformer any components in the Primary will appear on both buses of the Secondary, and therefore in every wire in the house.*

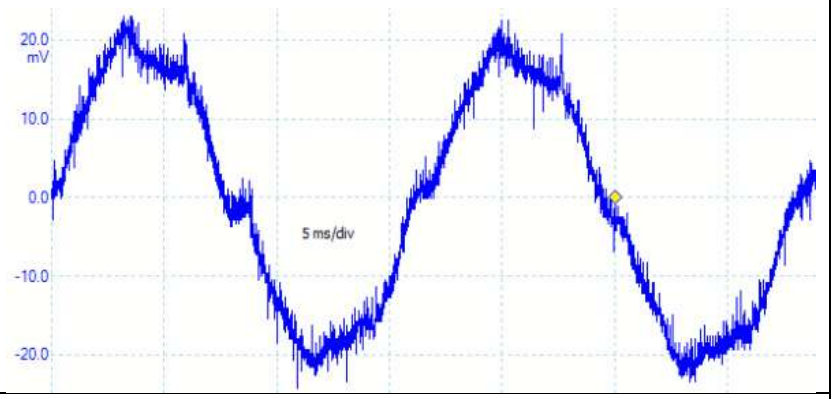


Sampling of an energized lead voltage *at the electrical panel, <u>with power off.</u> Sampled before the breaker.*



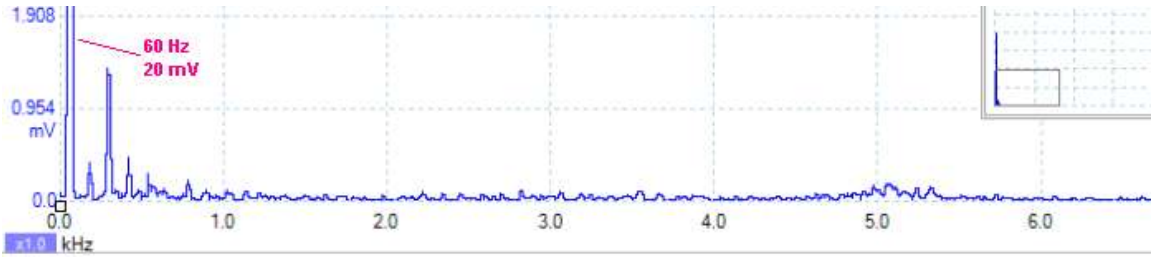
Site G: Lance Conway's

Horizontal Magnetic *field, intermittently fluctuating between 15 and 30 mV peak*



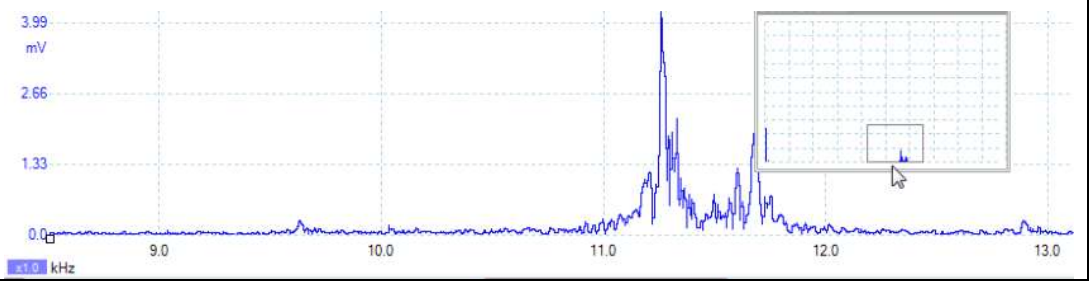
What appears to be power frequency harmonics to 2 MHz

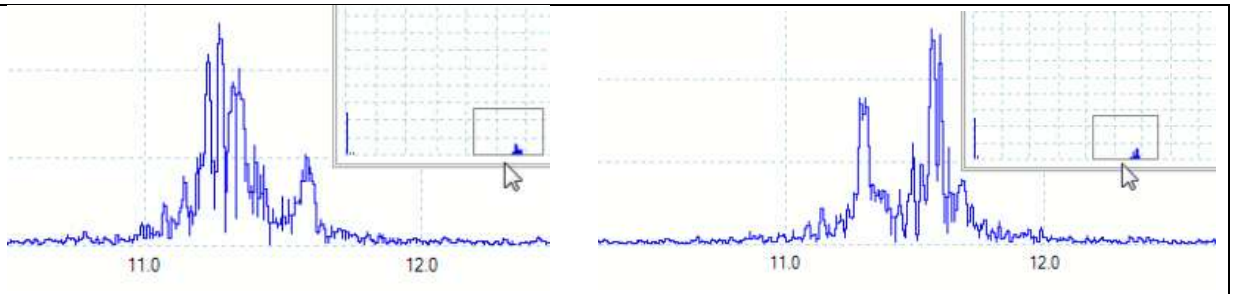
Very pronounced EMI at about 27.5 KHz



Power Frequency harmonics (first block), and EMI

Unknown EMI – very similar to Ginger's house at 16 KHz

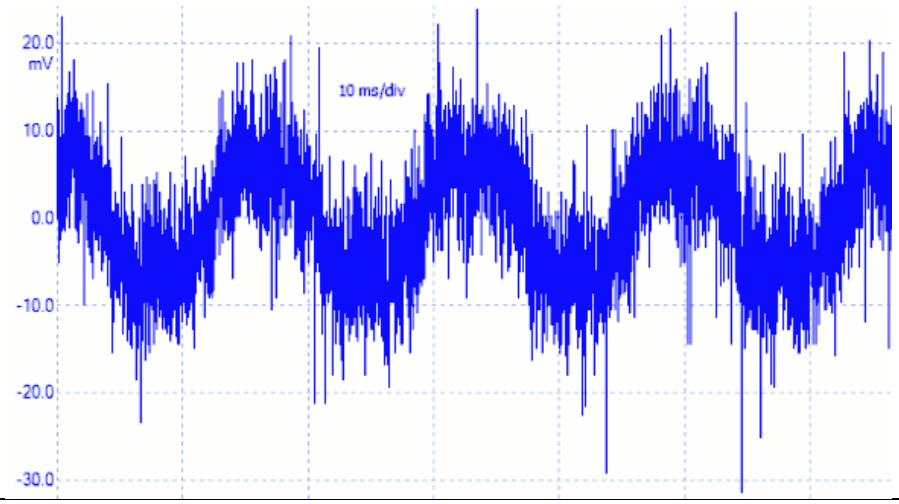




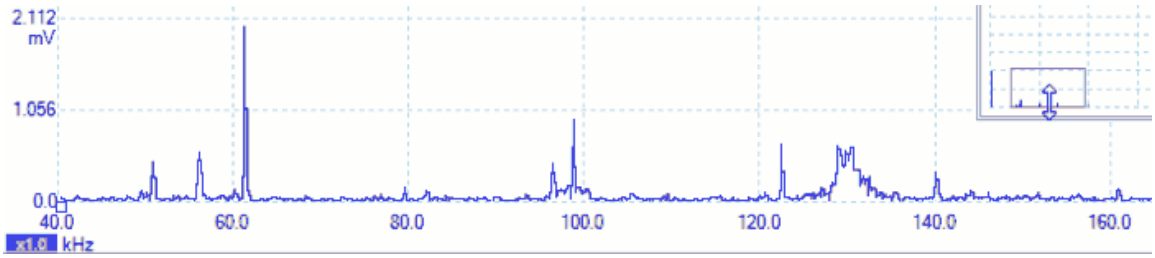
Two views of the same EMI as above, seconds apart

Site H: By Turbine

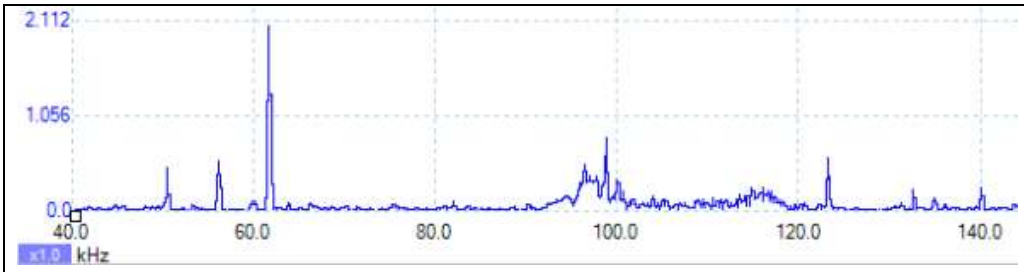
Electric field *pickup on a long wire (~ 20') horizontal antenna*



Power frequency harmonics?

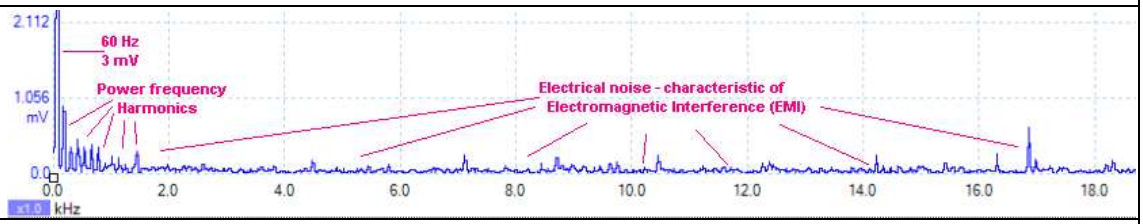


Wide-band EMI, each group sporadically going up and down in frequency

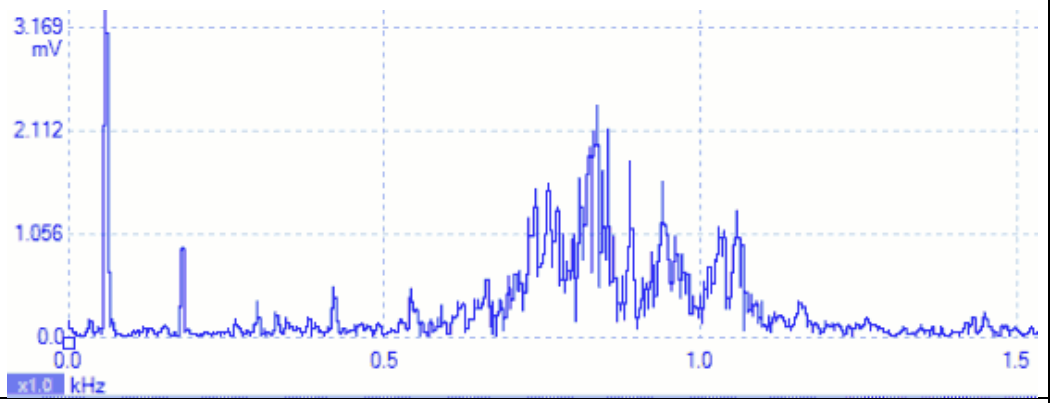


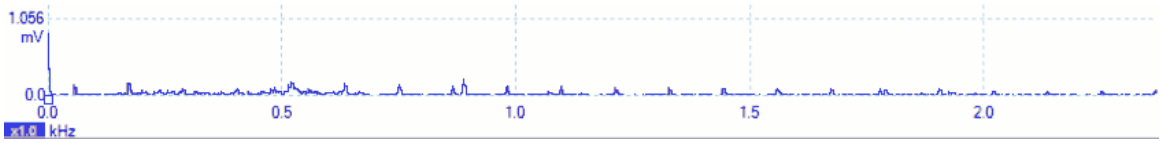
Same as previous EMI, a few seconds later

Harmonics and EMI



A few harmonics and much EMI

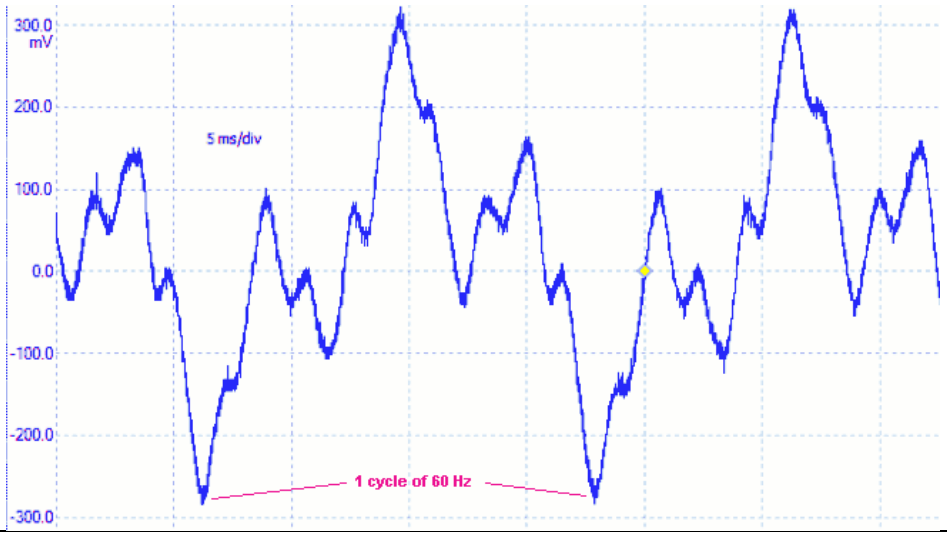




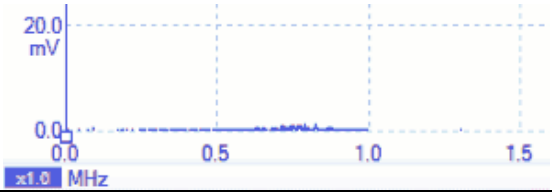
Magnetic field pickup, EMI

Site I: SDG & E Boulevard Substation

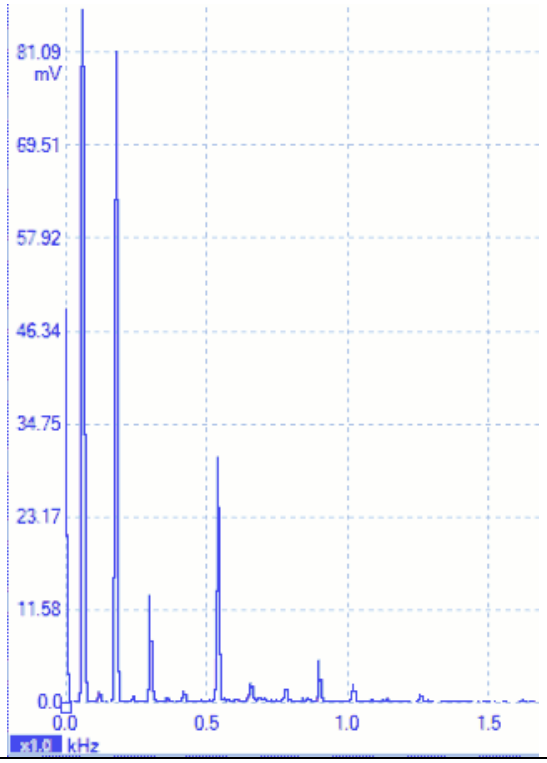
Vertical Magnetic *field, Ground Current returning to sub – Note that this is three-phase power, as identified by the peculiar peak arrangement for each cycle of 60 Hz*



Wide-band EMI, same as at Site F, and Ginger's, and very similar to Rowena's

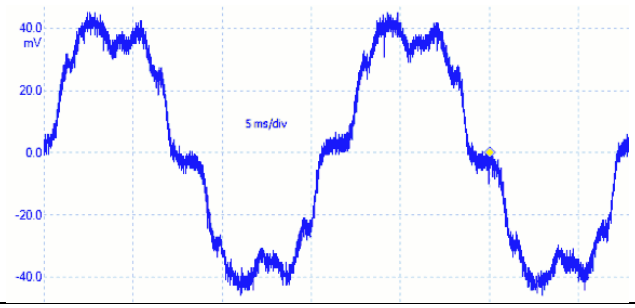


Power frequency harmonics

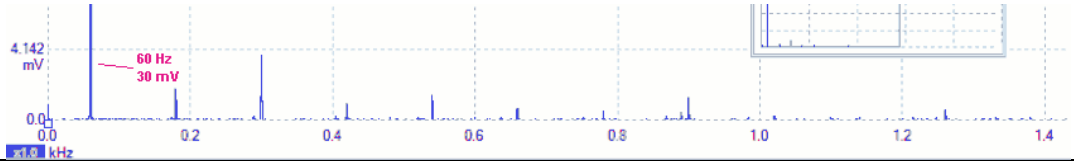


Site J: Jim Pelley's

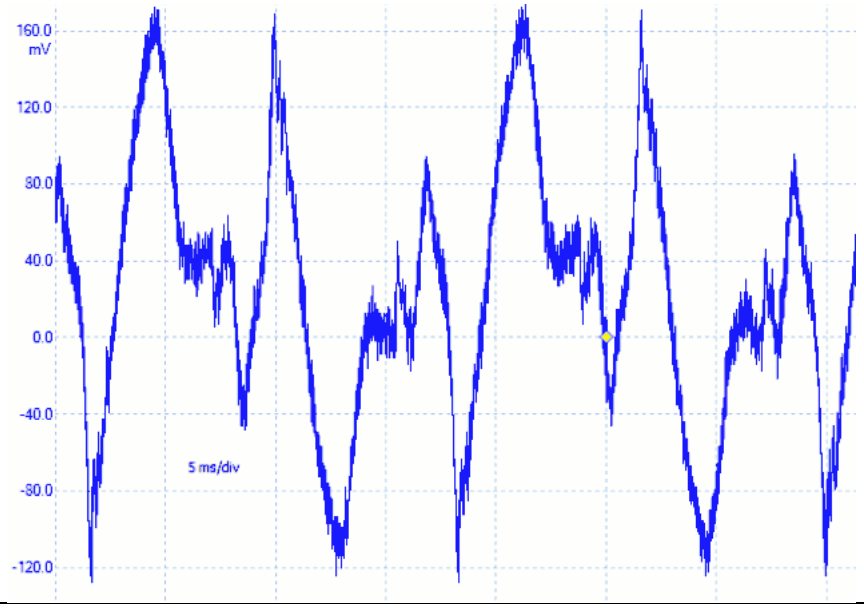
Horizontal Magnetic *field over the underground feed to the house, with power on. This is a combination of grounding current for the power system as well as the house. Is the primary contributor the power line, or the user appliances? Note that there is a three-phase signature, which is clearer on the next page with a power off measurement.*



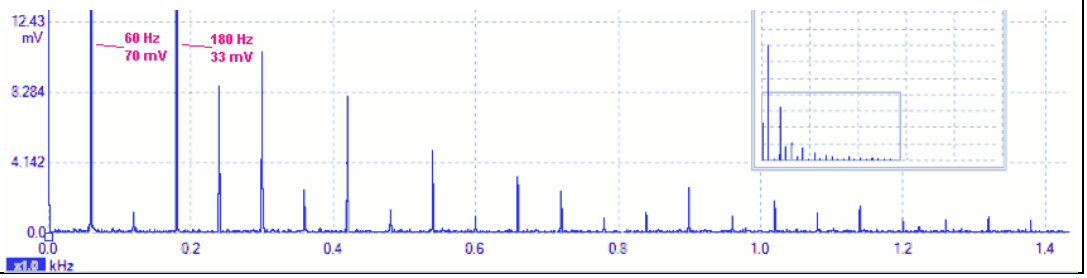
And its correspon ding spectrum



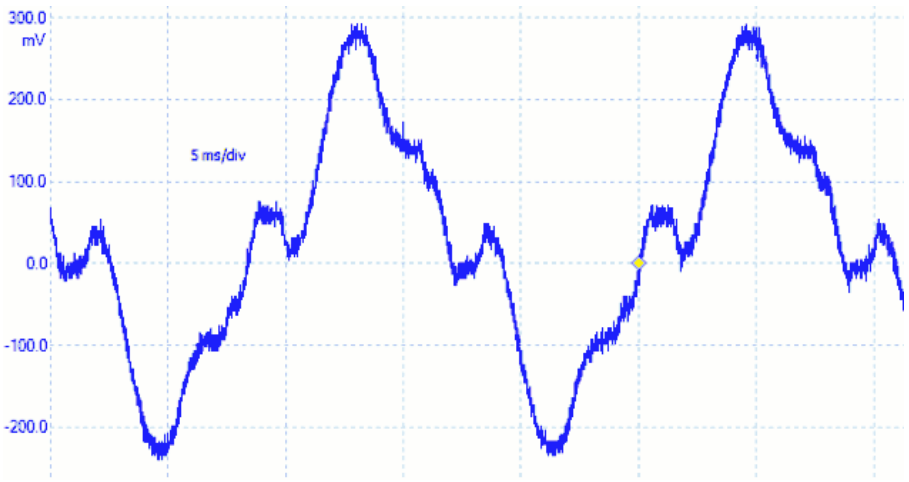
The same measurement, about one minute later. Is the primary contributor the power line, or the user appliances?



And the correspond ing spectrum

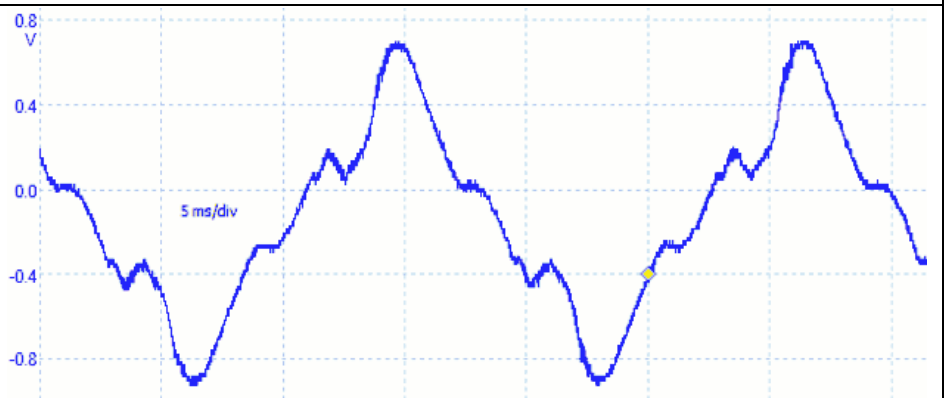


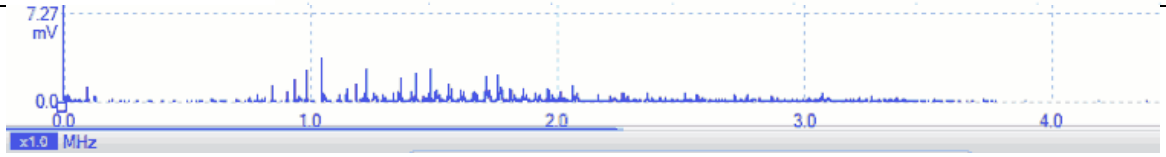
Horizontal Magnetic *field over the underground feed to the house, with power off. Note that this is three phase power grounding current. Even though the supply to the house is single phase, the imbalance on Primary Neutral from the 3-phase system is using the residence ground to return current back to the substation.*



Electric field pickup with wide-band EMI

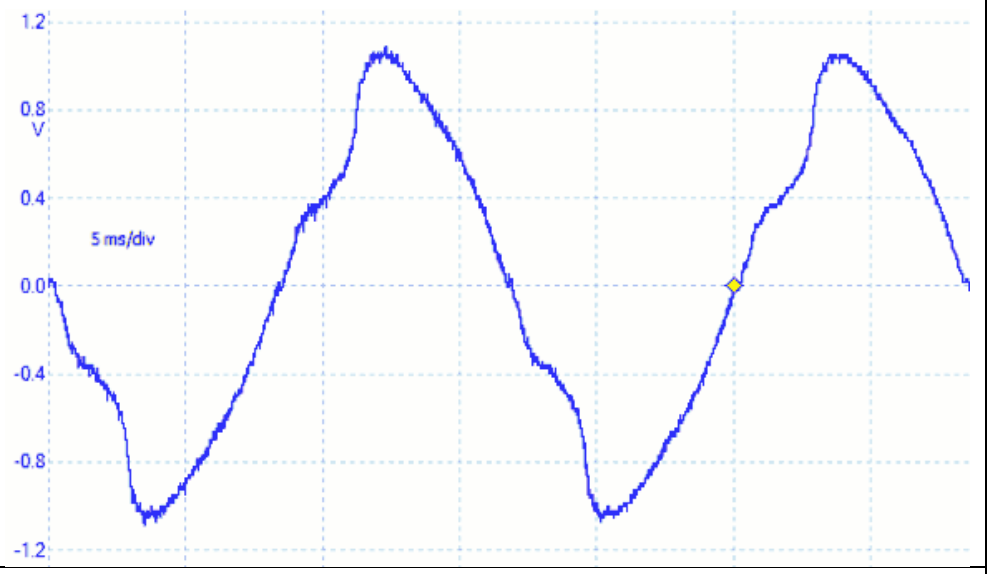
Neutral to Earth voltage *with power off. Note that this is a three-phase signature.*

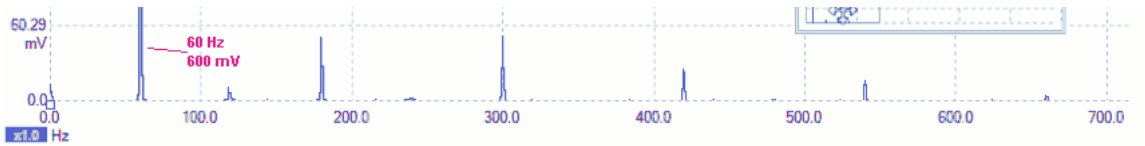




Neutral to Earth voltage *with power off – wide-band EMI*

NET current *contribution from residential use to the Neutral, which would share some of its current through the soil. The scale is 100 mV/A, equating to about 7.5 Amps. Perhaps 30% of this will find its way back to the source via the soil.*

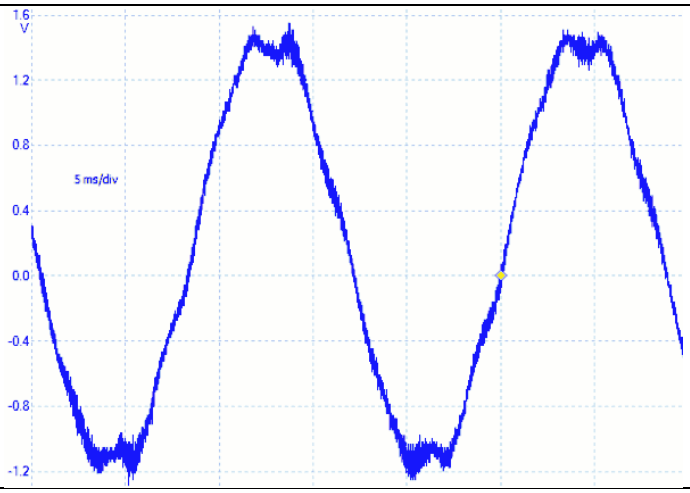




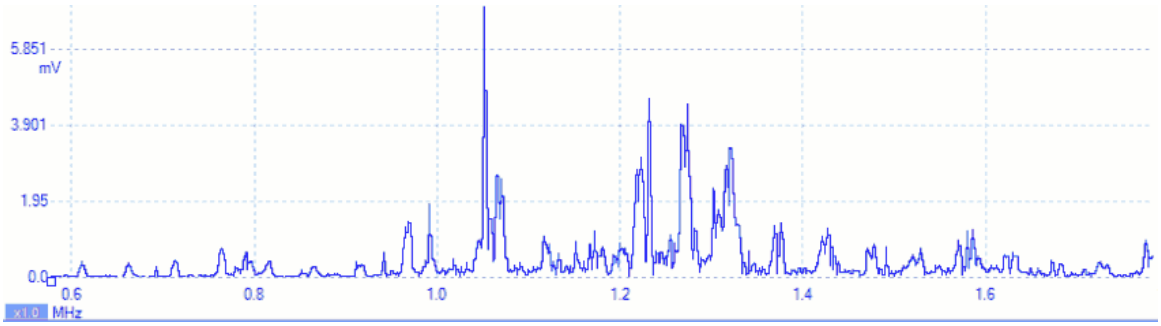
And its corresponding spectrum. Note the relatively few power frequency harmonics.

Site K: Parke Ewing's

Neutral to Earth Voltage with power off.



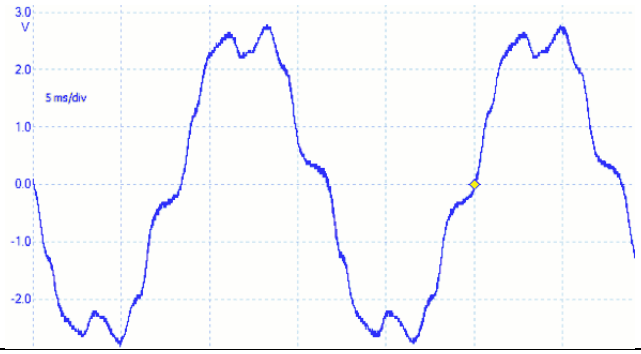
And the corresponding spectrum.

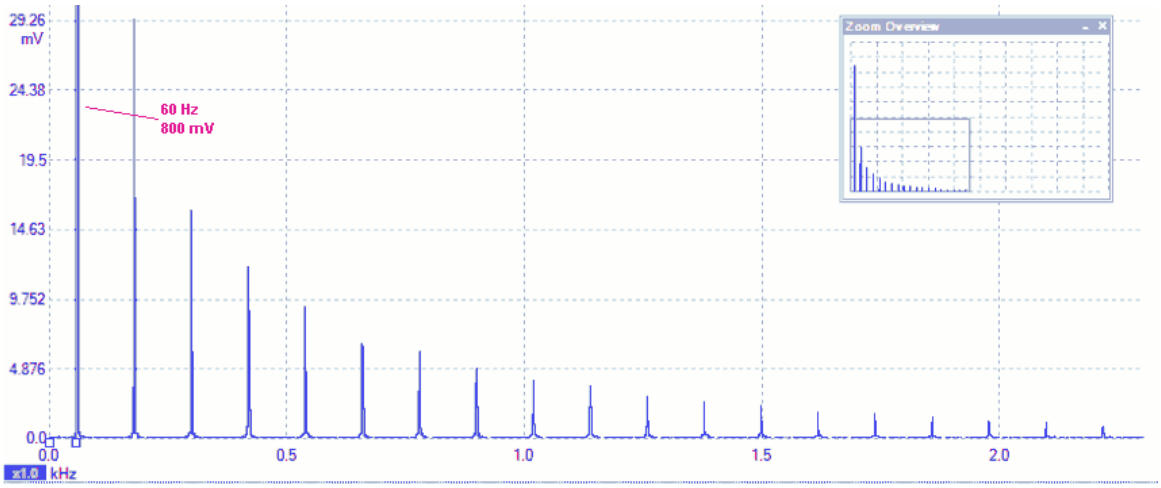


Neutral to Earth Voltage with power off – wide-band EMI

A bus voltage with power on.

B bus nearly identical.





And the corresponding spectrum.

Appendix B: AC Power Non-linearity, Harmonics, Points of Reference, and Wiring-error Identification Tracing and Correction Protocol

There are two fundamental phenomena in Alternating power systems that are of interest. The first is a **Transient**. These are momentary perturbations of the Alternating Power System's Sine Wave and any related field, and occur whenever something is turned on or off. These transients can propagate (and be detected) for miles within interconnected systems. That is, in systems such as WYE, anyone turning a lamp on / off will produce an instantaneous transient electrical change that will propagate through the power source to all interconnected branches of the circuit. Since the electric distribution in each residence can be thought of as two hands (the buses) with many fingers (the circuits), anytime a switch is operated in any of the circuits, all circuits associated with a bus will experience the transient directly. To illustrate the point, when the refrigerator turns on, the lights on that bus will momentarily dim substantially, and remain dimmer to a lesser extent until it turns off.

Each transient will produce the second phenomenon of interest, a broad but momentary spectrum of **Harmonics**, or multiples of a fundamental frequency required to produce the step change in voltage / current. A simple and tangible display of this is provided with lightning, in that each stroke of non-alternating current will blanket the frequency spectrum, producing electric static through all frequencies from zero Hertz to the Megahertz MHz region, blanketing all AM radio frequencies.

Unfortunately, some devices produce these transients for each pulse of energy, or twice per cycle (120 transients per second). Thus if 180 or 300 Hertz (Hz) is produced by a switching condition, and it occurs 120 times per second, the 180 / 300 Hz is also available 120 times per second, which may be considered a continuous presence. This can be compared to a bird chirping a note intermittently, and then somehow doing it so frequently that it appears to be a constant tone. Some of these devices are fluorescent lighting of any type, dimmer switches, and switching power supplies. When such devices are energized, they will produce many harmonics easily detectable with an AM radio. Another telltale indicator is that the label on most of these devices depicts any input as acceptable between 90 to 250 V. **Since the current used by these devices does not resemble the applied voltage, the device is designated as non-linear**.

Electricity can have plenty of non-linearity, based on how the voltage available is allowed to produce current, and productive work. Non-linearity occurs when anything is powered, and whose response to applied voltage is anything other than that of a hot wire.

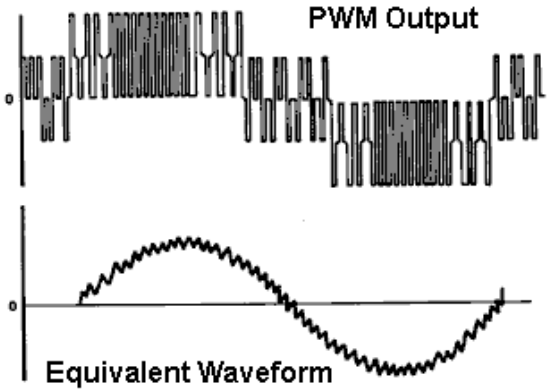
Since most individuals on this planet who have electricity also have non-linear loads, most of those individuals also contribute to the non-linear mix that eventually may find itself routed to undesired places.

When we look at the power we use, when it involves a hot wire (incandescent lamp, toaster, etc.) the current produced is an exact replica of, and synchronized with, the applied voltage. On a meter it would be a number, on an Oscilloscope it would have a shape similar to lazy S (~), and on a Spectrum Analyzer it would be a single vertical marker on a vast universe of frequencies that we commonly call the Electromagnetic Frequency Spectrum.

When the power is used by anything other than a hot wire (fluorescent lamp, dimmers, digitals, VFD,

PWM, etc.) the resulting current no longer looks like the voltage used to produce it. On a meter it would be a number (but some meters are now dramatically affected by the many frequencies required to produce that shape), on an Oscilloscope it might look like a peak, triangle, etc., and on a Spectrum Analyzer it would look like a choir of many frequencies decreasing in size as the frequency increases.

When the generation of power is associated with wind turbines there are some additional and unusual problems. Primarily there is the link-up to the power system when they begin to generate power, and similarly when they go offline due to lack of wind. Since the blades vary their speed with the wind, and they move at extremely low speeds, the speed must be increased by a gearbox or transmission, which has a fixed gear ratio. This presents a problem, because the generator's rotational speed varies, but the electrical system interconnection frequency does not. One way around this is by a PWM VFD. That is, a Pulsed Width Modulated Variable Frequency Drive. These devices produce very steep electrical changes (or transients, that produce lots of harmonics) to eventually produce a "smooth" voltage to be fed to the generator for excitation, as depicted in the sketch below. Unfortunately these very steep electrical changes Induce voltages and currents in the rotor that cause electric discharge machining (EDM) between the bearings and the races they fit into, causing pitting of the races. This can make the generator fail in as little as six months. An elegant solution to eliminate the induction is to short out these voltages and currents with an electrically conducting collar around the generator's shaft. However, this elegant solution shorts out the voltages and current to ground, and remembering that the various ground connections have instantaneously different voltages, some of the current flows through the soil between the different grounds, which is also known as **Stray Current**.



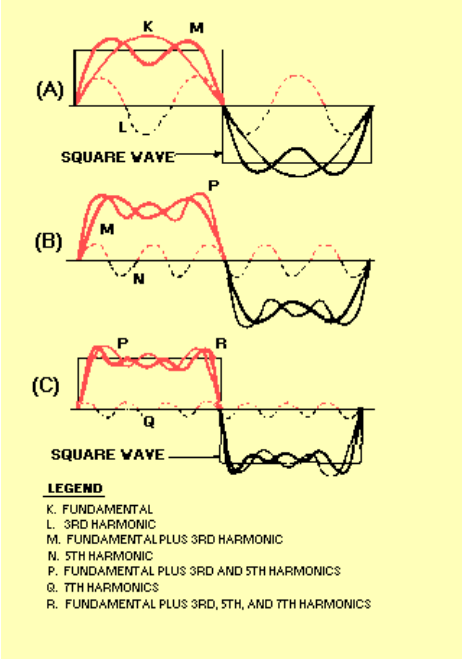
PWM VFDs are Switch-mode Power Supplies, and they produce steep waveforms to produce the desired output. The steepness of the changes varies the harmonics presence, in that the steeper the waveform, the broader the frequency span of the harmonics required to produce the waveform.

COMPOSITION OF NONSINUSOIDAL WAVES – Excerpted from: NEETS (Navy Electrical and Electronics Training System) Module 9 – Wave Generation and Wave Shaping circuits

Pure sine waves are basic wave shapes from which other wave shapes can be constructed. Any waveform that is not a pure sine wave consists of two or more sine waves. Adding the correct frequencies at the proper phase and amplitude will form square waves, sawtooth waves, and other non-sinusoidal waveforms.

A waveform other than a sine wave is called a COMPLEX WAVE. You will see that a complex wave consists of a fundamental frequency plus one or more HARMONIC frequencies. The shape of a non-sinusoidal waveform is dependent upon the type of harmonics present as part of the waveform, their relative amplitudes, and their relative phase relationships. In general, the steeper the sides of a waveform, that is, the more rapid its rise and fall, the more harmonics it contains.

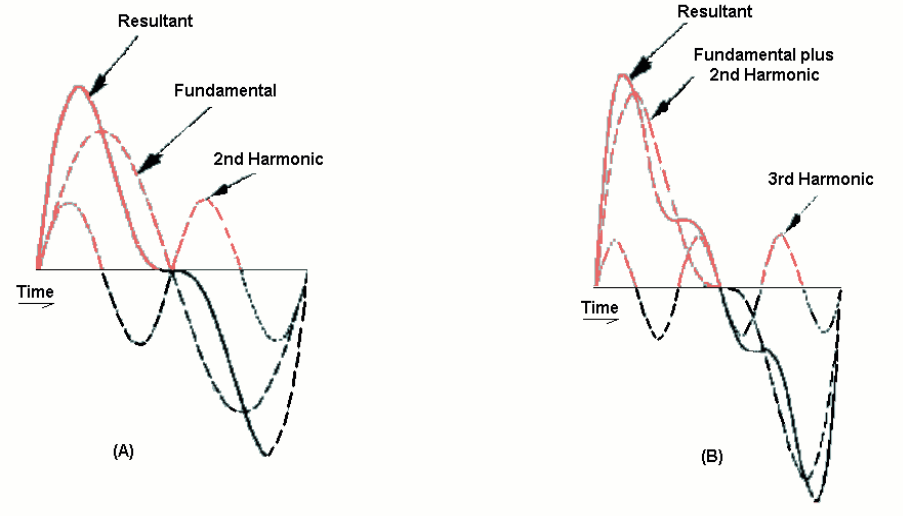
The sine wave which has the lowest frequency in the complex periodic wave is referred to as the FUNDAMENTAL FREQUENCY. The type and number of harmonics included in the waveform are dependent upon the shape of the waveform. Harmonics have two classifications - EVEN numbered and ODD numbered. Harmonics are always a whole number of times higher than the fundamental frequency and are designated by an integer (whole number). For example, the frequency twice as high as the fundamental frequency is the SECOND HARMONIC (or the first even harmonic).



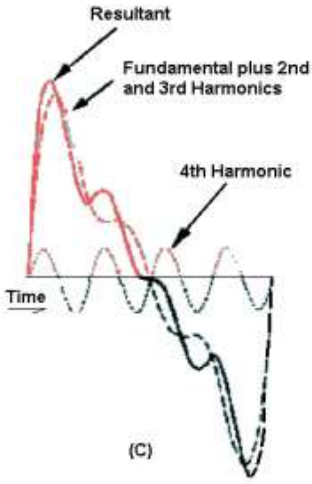
View (A) of the figure on the right compares a square wave with sine waves. Sine wave K is the same frequency as the square wave (its fundamental frequency). If another sine wave (L) of smaller amplitude but three times the frequency (referred to as the third harmonic) is added to sine wave K, curve M is produced. The addition of these two waveforms is accomplished by adding the instantaneous values of both sine waves algebraically. Curve M is called the resultant. Notice that curve M begins to assume the shape of a square wave. Curve M is shown again in view (B).

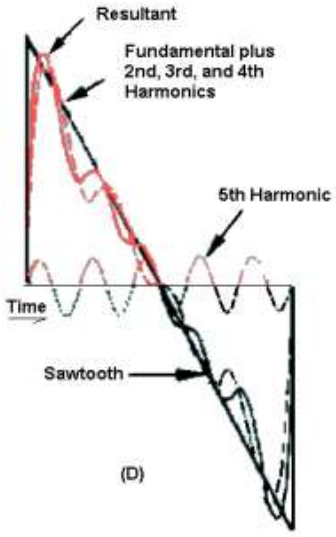
As shown in view (B), when the fifth harmonic (curve N with its decreased amplitude) is added, the sides of the new resultant (curve P) are steeper than before. In view (C), the addition of the seventh harmonic (curve Q), which is of even smaller amplitude, makes the sides of the composite waveform (R) still steeper. The addition of more odd harmonics will bring the composite waveform nearer the shape of the perfect square wave. A perfect square wave is, therefore, composed of an infinite number of odd harmonics. In the composition of square waves, all the odd harmonics cross the reference line in phase with the fundamental.

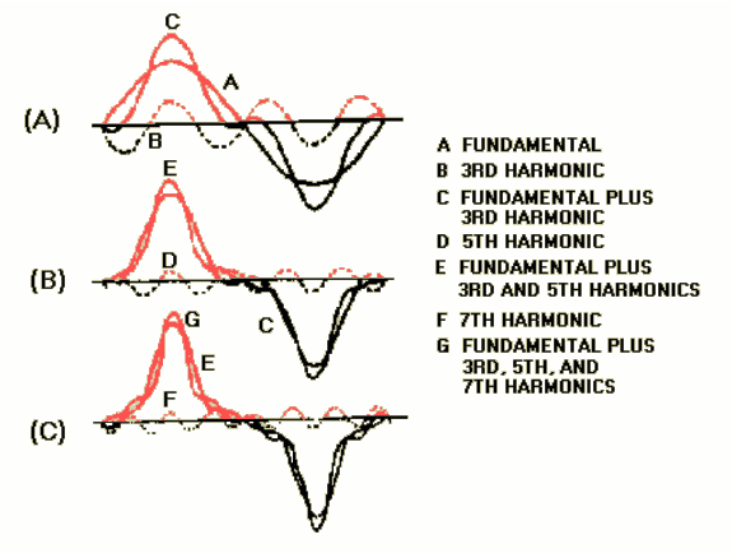
A sawtooth wave, shown on the right, is made up of both even and odd harmonics. Notice that each higher harmonic is added in phase as it crosses the 0 reference in view (A), view (b), view (C on the next page), and view (D on the next page). The resultant, shown in view (D), closely resembles a sawtooth waveform.



The figure below shows the composition of a peaked wave. Notice how the addition of each odd harmonic makes the peak of the resultant higher and the sides steeper. The phase relationship between the harmonics of the peaked wave is different from the phase relationship of the harmonics in the composition of the square wave. In the composition of the square wave, all the odd harmonics cross the reference line in phase with the fundamental. In the peaked wave, harmonics such as the third, seventh, and so forth, cross the reference line 180 degrees out of phase with the fundamental; the fifth, ninth, and so forth, cross the reference line in phase with the fundamental.







The reason these harmonics are of importance, is that their end-product, the characteristically sharp waveforms, have ease of penetration through the skin boundary and can interact with the central nervous system (CNS) directly *(TENS instruments (to alleviate pain) and TASER guns (to inflict pain, or immobilize) function based on this principle, the difference simply being one of magnitude)*. The CNS functions with electric pulses for communication and control. Should the waveforms impressed on the body be of similar waveform as those associated with the CNS or of similar frequencies, or of other frequencies of biological importance (such as brain waves), then these external contributors can cause undesirable biological responses, that may consist of pain, diffuse irritation, etc. Many of the harmonics are within the hearing range (20 to 20,000 Hz), the flicker associated with certain type of lighting is within the range of frequencies that can cause epileptic seizures, so a variety of biological interactions are certain, differentiated in each circumstance due to a large number of variables.

It is in the best interest of anyone subjected to Alternating fields to reduce them to the greatest extent possible following the ALARA principle (As Low As Reasonably Achievable). **Electric Field reduction indoors** can be achieved inexpensively by removing energized devices from the bedside (lamps, alarm clocks, radios, etc.), and using daylight as much as possible during waking hours. **Electric Field reduction outdoors** is greatly aided by tree plantings, as they are in intimate contact with moist soil (grounded), are conductive, and shunt the electric field from a source, preventing it from getting to the other side. This is especially effective when the trees are planted between a house and a nearby power line. **Magnetic Field reduction from ground current** is difficult to accomplish at the individual level owing to the many sources interconnected to the soil, and Neutral Isolation from the supply transformer will greatly help to reroute long-distance cartage of ground current to/from sources. **Magnetic Field reduction from wiring errors,** which are common indoors but were not investigated, is easily accomplished using the protocol included at the end of this Appendix. **Wide-band Energy reduction** is at the core of the biological exposure due to many frequencies involved that are also themselves changing amplitude dynamically depending on what device(s) is(are) energized. Neutral Isolation will help in part from a communal level, regardless of the source, and individual measures as described below will help at the individual level.

Some of those measures, beginning with those that are least-cost include:

a) turning off,

b) unplugging (relative to devices that have stand-by circuit power usage),

c) replacing with alternatives, or

d) limiting usage of:

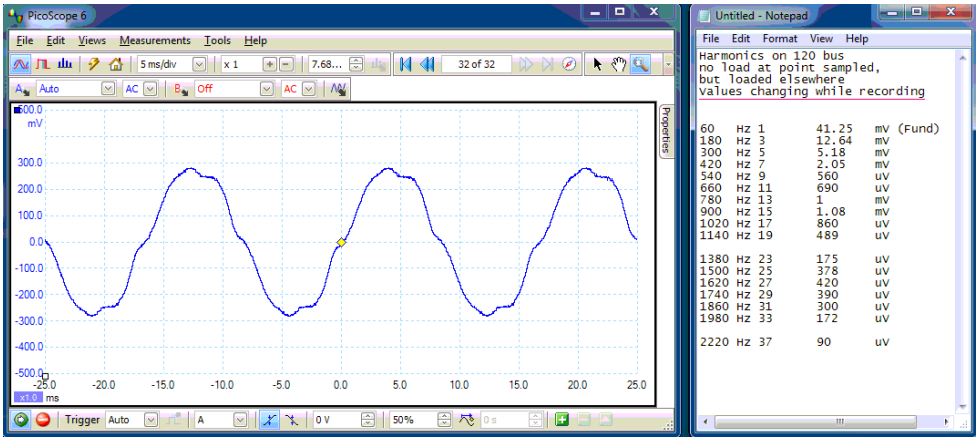
1) Compact Fluorescent lamps,

2) Fluorescent lamps in general,

3) Dimmer switches,

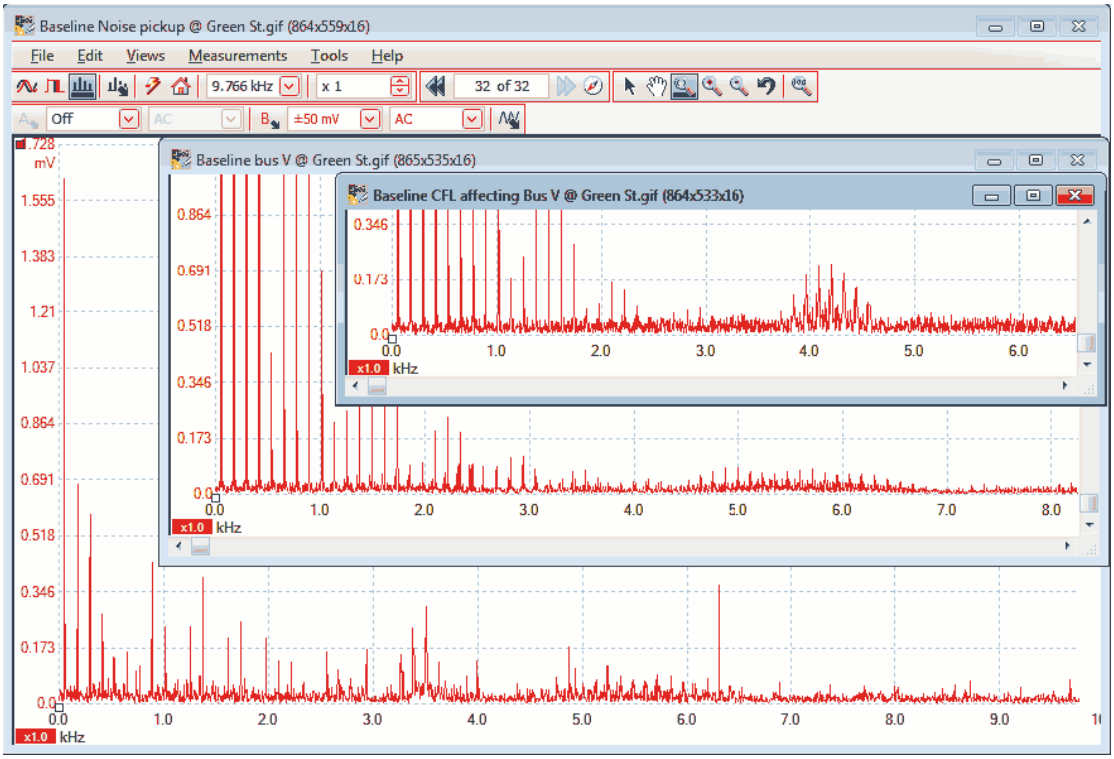
4) Digital devices in general.

Points of Reference



Above is a graph of one of the 120 V supplies in a house distant from the test sites. Note that although the 120 V is reasonably smooth, whatever loads are in service before the point of measurement, they impact the smoothness of the supplied wave, because there is about 100' of cable between the supply transformer and the applied load, causing a voltage loss between the source and the load. The voltage was sampled with a reduction scheme to protect the equipment, and the peak should be 170 V. So multiplying by 560 will provide calibrated data. Note in the table attached to the graph that all of the detected frequencies were harmonics, and they quickly diminished in size. Compare that to the table to the right of the Current of a Compact Fluorescent Lamp, and note that some frequencies are not 60 Hz harmonics, and their size does not diminish easily with increase in frequency. Due to Ohm's Law, a voltage will be developed at the panel that will subtract from the available 120 V that matches the waveform of the CFL current, highlighted to the right in red. A voltage will also be produced at the neutral/ground wire that will also match the waveform. However, since the load (house) and the source (transformer) are both grounded, some of the current will flow through the soil matching the frequency characteristics of the CFL signature.

Harmonics on 120 bus Current – Compact Fluorescent						
F		Harm #	Value			
60	Hz	1	132	mV (Fund)		
180	Hz	3	107	mV		
300	Hz	5	72	mV		
420	Hz	7	50	mV		
505	Hz		3	mV		
540	Hz	9	36	mV		
624	Hz		2.9	mV		
660	Hz	11	27	mV		
744	Hz		4	mV		
780	Hz	13	18	mV		
860	Hz		4.3	mV		
900	Hz	15	19	mV		
984	Hz		4.7	mV		
1020	Hz	17	19	mV		
1103	Hz		4.8	mV		
1140	Hz	19	16.5	mV		
1224	Hz		5.5	mV		
1260	Hz	21	13.6	mV		
1343	Hz		5.6	mV		
1380	Hz	23	13	mV		
1464	Hz		5.7	mV		
1500	Hz	25	11	mV		
1585	Hz		5.7	mV		
1620	Hz	27	10.4	mV		
1704	Hz		5.8	mV		
1740	Hz	29	11.4	mV		
1823	Hz		5.5	mV		
1860	Hz	31	10.1	mV		
1943	Hz		7.5	mV		
1980	Hz	33	9.6	mV		
2063	Hz		7.6	mV		
2100	Hz	35	8.3	mV		
2183	Hz		8.4	mV		
2220	Hz	37	7.8	mV		
2303	Hz		7.9	mV		
2340	Hz	39	8.2	mV		
2424	Hz		9	mV		



Pictured above is measurement of Voltage using the same scale to qualify the Picoscope and the impact of a single low wattage device, namely a Compact Fluorescent Lamp (CFL), rated at 14 Watts.

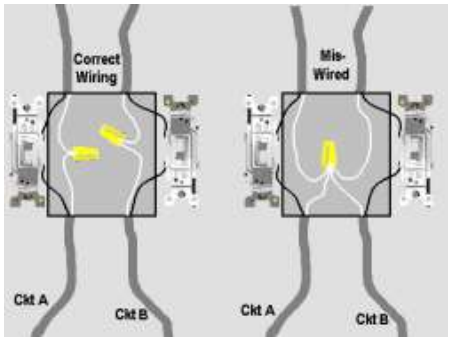
The appliance wattage rating implies a current flow of 116 milliAmps (mA) or 0.116 Amps. What should be enlightening is that for a system where the typical minimum full-load circuit specification is 15 Amps (common across North America), such a low current "energy saving" appliance should not impact the Voltage provided to it. But it does.

Careful observation of the Red waveform in the last picture on the previous page, and its scale, will disclose that the little CFL is using instantaneous current demands, twice per cycle, of 800 mA, or about 7 times the RMS wattage (*RMS being a historical construct whereby all AC power usage can be directly compared to DC power usage. For instance when 120 V is quoted, the voltage is given in RMS values, although the peak is actually 170 volts, twice per cycle*.).

What can be noted from the picture above is that the Picoscope is a very sensitive device, and with leads connected but without any signal input, it will pick up stray signals from any Electric field source nearby (the lower graph). The moment voltage is provided to the cord being measured, a voltage is sensed by the Picoscope, and a corresponding spectrum emerges, specific to 60 Hz and the various power frequency harmonics present from whatever loads are applied to the bus measured, elsewhere in the house (the middle graph, 45 mV @ 60 Hz vs. a prior 1.5 mV). When the CFL is energized (top), the power frequency harmonics below 2 KHZ remain unaffected, but those above 2 KHz emerge as a new signature specific to the CFL, along with a diffuse but pervasive increase in the electrical noise floor.

When one considers that the typical North American home is outfitted with NM/Romex wire, and that structural materials are transparent to Alternating Electric fields, it should be obvious that the electrical noise emissions from even a single CFL become a whole-body exposure phenomenon.

Protocol for Wiring Error Tracing and Correction

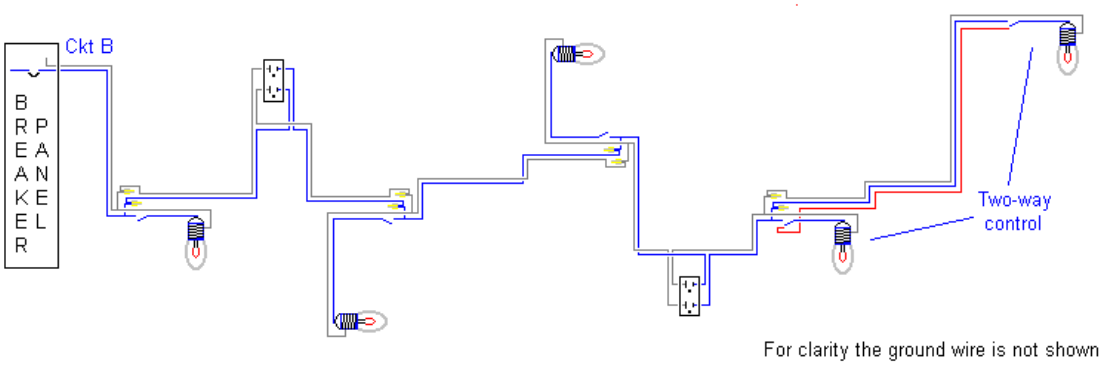


As long as the Supply and Return wiring are in the same cable as shown in the simplified sketch below, their respective currents' Magnetic fields are of opposite polarity and cancel except within a foot or so of the cable. If the return wiring for one circuit is interconnected with another at a junction box with a couple of switches, as an example and as shown on the sketch to the right, then the return current sees more than one path back to the panel, the supply and return currents no longer cancel, and produce a magnetic field in free space bounded by the routes of both circuits. The magnetic field will exist whenever either circuit is in use.

Wiring errors can happen inadvertently, such as a neutral insulation being scratched in the process of inserting a switch or outlet into its box. This may create an instantaneous Neutral to Ground fault. Another is where Neutrals from two or more separate circuits are interconnected at a common meeting place, like switches in a common box, as shown in the above sketch.

To test for wiring errors, open all breakers. Lift a single Neutral from the neutral bar and check for voltage, if there is no voltage (*voltage indicates a more complex wiring error*) then check for continuity between the lifted neutral and the neutral bar. The two possible outcomes are continuity or no continuity. Continuity indicates a wiring error, because with all circuit breakers turned off, and the neutral lifted from the panel, it should have not return connection back to the panel anywhere, as per the sketch depicting a typical circuit below. No continuity indicates a properly wired circuit.

What remains for the electrician is to identify the breaker(s) associated with the respective circuit, turn it (them) off, turn off all other circuit breakers mis-wired to prevent a current back-feed, and lift the Neutral from the Neutral bar. A signal can then be injected (or a continuity test set up) between the neutral and the neutral bar, and the signal will follow the path of, and be traceable through, the entire length of the route of the interconnected circuits. The time-consuming aspect is that several points of use may need to be opened, sequentially, to identify where the wiring error exists. When the wiring error is found and corrected, the signal will no longer have a circuit loop to follow, and it will stop. Signal injection elsewhere will produce unpredictable results. When more than one circuit is mis-wired, it is likely that two or more are interconnected. What will then occur is that when one circuit error is traced, two or more will be corrected. So re-testing is required.



Appendix C: Multiple points of cancellation

For the North American market, residential power is delivered via two buses that are out of phase, or opposite polarity. Under ideal conditions, two matching loads powered from the different buses will cancel at their junction point, being the neutral. Under normal and non-ideal conditions some cancellation will not occur and a return current will attempt to flow back to the source transformer via the neutral. The only way to measure the Instantaneous contribution to the Neutral current from a residence is to measure both energized bus leads simultaneously. From an exposure perspective, without neutral redundancy, the matching currents on the wires to a residence are of opposite polarity and cause almost complete field cancellation except within a few inches to one foot from the cable.

All residential power in North America is provided as three phases, each separate from the other by 120 degrees. This can be visualized by considering a generator whose output consists of three windings physically 120 degrees apart. As the exciting coil spins within them, the voltages and currents in each of the output coils will be 120 electrical degrees separate from the others. At 60 Hz, 120 degrees would be 5.5 milliseconds of time difference. As a three phase system, if three identical loads were applied to each phase, they would cancel at their junction point, being the neutral. Under normal and non-ideal conditions some cancellation will not occur and a voltage will try to develop at the system neutral that directly corresponds to the amount of non-canceled current. Since all distribution substations have an excellent underground grid of bare wire designed to provide a very intimate contact with the earth's moisture layer, which is defined as the zero voltage reference, any attempt to develop voltage directly translates to current that will flow between the neutral at the substation and the neutrals attached to the various circuits, and underground via their multiple ground contacts scattered throughout the geographic service area.

When the power system Primary is a WYE configuration, the voltage is 7200. At a neighborhood transformer this translates to a voltage step-down of 7200/120, or 60 to 1. The opposite is true for current, in that a step-down in voltage is equivalent to a step-up in current. So for each 60 Amps of customer usage, there will only be 1 Amp of current flow in the primary at 7200 V. Since most homes' average power is no more than about 7 Amps, this translates to about 1/10 Amp on the primary. This implies that the Primary fields will be mostly Electric and minimally Magnetic. When the power is conveyed by Transmission lines at 69,000 Volts, a similar phenomenon occurs in that to arrive at 7200 there is a voltage step-down of 9 to 1. That implies that for every 9 amps of current at 7200, there will only be 1 Amp of current at 69,000 V. For 500 KV there is a similar relationship, so that as voltages get progressively higher, the currents get progressively smaller, reinforcing the previous relationship.

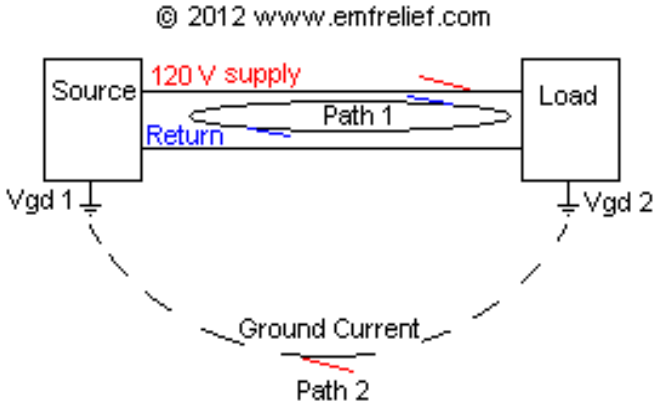
Measuring the difference in the Neutral-Earth voltage at the residence with power on and with power off will give a sense of the different voltage drive affecting current flow into and through the soil. With power off, it will simply be an indicator of Primary grounding current drive, when employed in a WYE configuration, and is also known as **Stray Voltage**. At the transformer this measurement will closely match the one at the residence with power turned off.

The only way to measure the instantaneous contribution to the Neutral current from a supply transformer is to measure both output leads simultaneously, which is generally not possible.

Appendix D: Ground / Grounding Current

Long distance power cartage suffers from Ohm's Law, which dictates that current flow in a wire will develop a voltage difference from one end to the other. This voltage subtracts from the voltage available at the end furthest from the source. Since electricity requires a round-trip loop between the source and the load, via the Supply and Return wiring, this same phenomenon will also produce a voltage on the return wire. If the return wire is grounded at the generator end and is considered to be at zero volts, at the load end it will no longer be at zero volts, when there is current flow. This phenomenon is easily noticeable, in that the voltage available at the local transformer may be 120, yet 100' away or so, with a little current flow the available voltage is no longer 120, but less, say maybe 118. As long as it remains above 114, all equipment functions properly, so there is great effort to ensure wire sizes are big enough to reduce its resistance, and the accompanying voltage loss to less than 5%.

Since the transformer (the source or generator) and the user premises (the load) are both grounded, and since the ground wire connecting them also has current flow, and two grounds are at slightly different voltages, relative to virgin soil, some current will flow through the soil. This is also known as Stray Current. This "leakage" will cause the feed to a house to be unbalanced (supply and return currents are NOT equal) and produce a concentrated Magnetic field about the feed wire, and a diffuse Magnetic field about the soil where the current may be flowing.



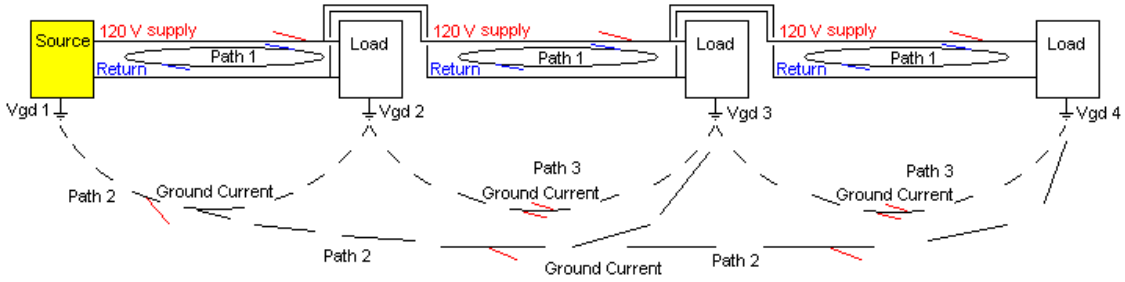
The grounding current does not occur at substations that are for transmission service exclusively, since they are not referenced to earth at both endpoints of their transmission lines (referencing any transmission line at one end is fine, but at both ends it is not). The reason the grounding is not interconnected between geographically distant substations is that there is sufficient DC voltage between such points from the Earth's DC planetary electric system to interfere with the stable operation of the alternating electric system. This causes the ground current phenomenon to be mainly a local phenomenon, wide-area geographically-speaking.

Voltage produces Electric fields, so proximity to power lines or indoor wiring will expose humans. **Current produces Magnetic fields**, so proximity to power lines or indoor wiring problems (a certainty in many homes) will expose humans. Current flowing through the soil, through paths unseen, will cause "unidentifiable" Magnetic fields and expose humans.

The Voltage on the Transmission and Distribution systems, is generally uncompromised, because the power conveyance is mostly in the form of voltage, and minimally current. That is, the Voltage would be a single frequency of 60 Hz. The Distribution Current, in contrast to Transmission current, will have some left-over remnants of customer usage, which would still be minimal due to cancellation effects previously described in Appendix B, and further reduced by the current step-down in the transformer.

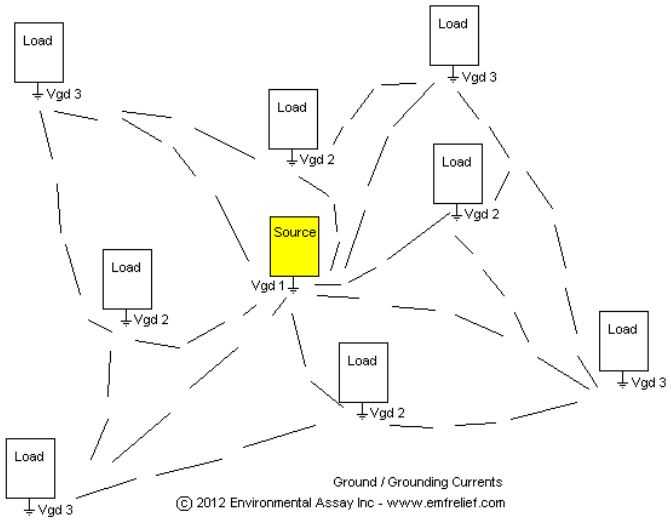
The current in the ground is mostly associated with Distribution systems' current, so it will have lots of non-linearity or Harmonics. Its magnetic field will expose everyone above it. A great portion of those harmonics are within the hearing range and close to other frequencies of possible biological importance, and exposure may cause unintended and widely divergent side effects, based on electric system characteristic and human variables.

When the power source and user is as shown in the simple sketch on the previous page, the possible paths of current are few. When the users are many, due to the many grounding points and the instantaneously varying potentials, the picture gets more complex, as shown below. Since the supply and return wiring are next to each other, there is interaction between their currents' magnetic fields, and a resultant restrictive effect. However, since the current flowing through the soil may not be immediately next to supply or return wiring, there is little interaction between its own and any other magnetic fields, and the restrictive effect is not there. The importance of the restrictive effect is that it is more pronounced at higher frequencies, so that there may be a tendency for the higher frequencies to flow through the soil, and the lower frequencies to flow through the wiring.



Ground / Grounding Current – Profile view

When the electric environment involves widely scattered loads as shown in the greatly simplified sketch to the right, with instantaneously varying ground contact voltages, the ground current may flow to/from any load, between loads, and to/from the source. The only means of reducing this flow is by an ungrounded electric system, or by Neutral isolation at the user location.



Ground / Grounding Current – Aerial view

When the authors attempted Ground Current measurement North of the Ewing reference, in open desert, rods were stuck in the soil in an East-West direction, and nothing was detected. One rod was relocated so that the detection arrangement was North-South, and a tell-tale 60 Hz and harmonic signature emerged (*When placing metal rods in the soil such that they "straddle" any possible flow of current, their electric potential will be the same and no voltage will be detected. When placing metal rods in the soil such that they are parallel with the flow of current, may divulge a 60 Hz and harmonic signature, because of the soil's electrical resistance between the rods. This is complicated by the ground current flowing through layers of soil whose depth below the surface is uncertain, and whose eventual route is also uncertain due to the non-homogeneity of the soil*.). Using the HF3851A Gaussmeter the author verified the presence and direction of the ground current, as it lined up with the flow corresponding to a North-South direction, and whose strength was about 1 nT, or about 0.01 mG. The reading should have been zero.

North is at top