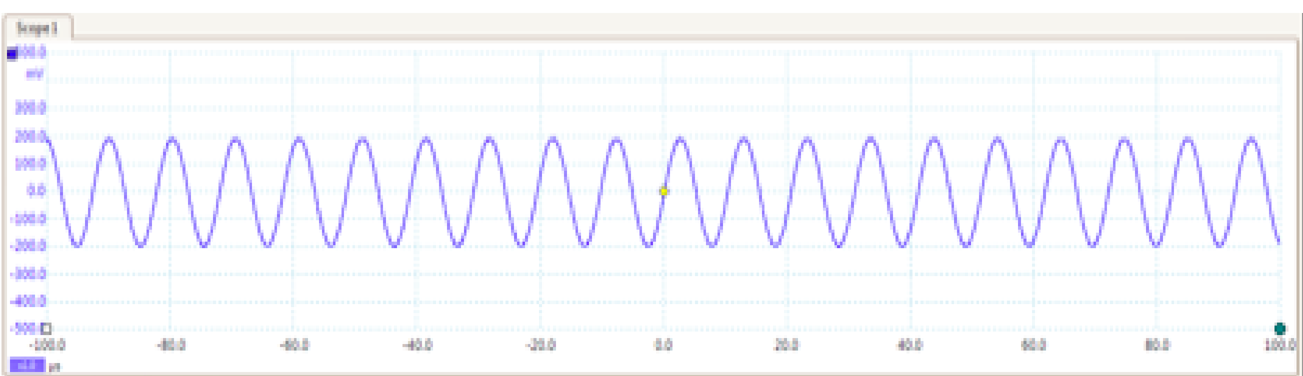
Metering And Testing With Advanced Instruments

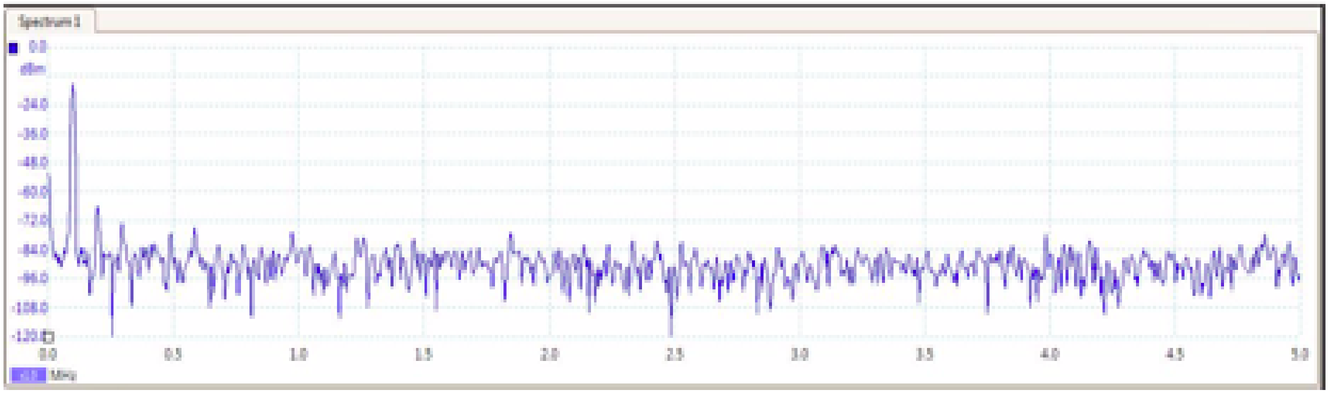
In discussion with some technical colleagues, the topic of "dirty electricity" inevitably creeps in. As I reviewed the easily accessible literature, it became obvious that the various presentations were either erroneous by ignorance, or erroneous by deception in order to achieve some business goal. Trying to level the playing field, and counter the BS, requires more detail than a simple numerical meter can provide, so below is a taste of advanced test and measurement, that you can also do (*inexpensively, I might add*).

Basic necessary pre-test requirements and foundational facts (*bear with me, they will all make sense*):

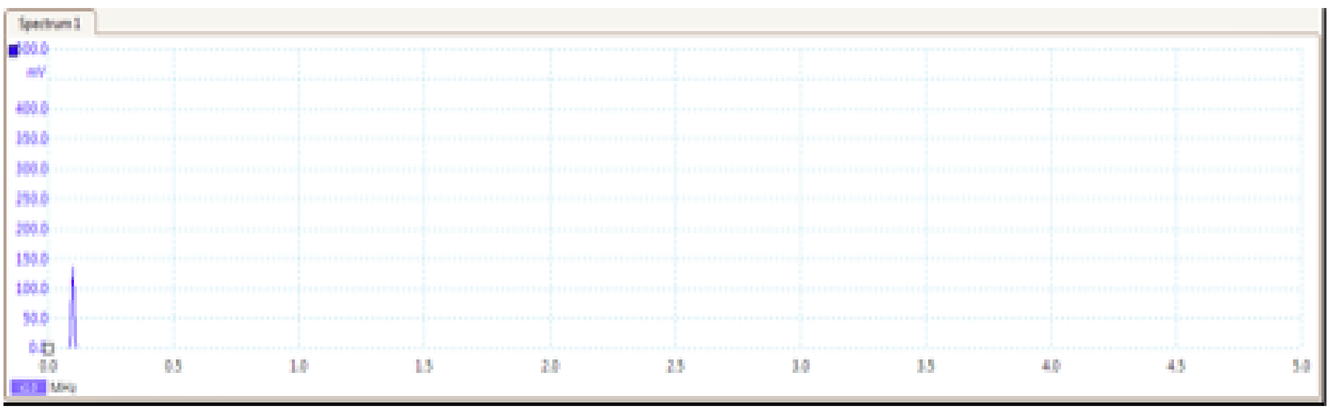
> The environment assessed does not have any wiring errors that can produce Magnetic fields in free space (*without wiring errors, the supply and return currents' respective magnetic fields overlap, and being of opposite orientation, cancel, except in the immediate vicinity of the cable*).
>
> The environment assessed does not have shared / redundant / parallel Neutral return current paths, that can create a Magnetic field in free space (*any pre-existing externally-sourced magnetic fields need to be accounted for, to determine if any internal contribution interact(ed) with them*).
>
> The monitoring / assessing equipment needs to be operated on batteries.
>
> The monitoring / assessing equipment needs to be qualified as for flatlining (*no waveform except minor internal instrument noise*) without an input, and properly rendering known inputs.
>
> The monitoring / assessing equipment needs to be operated in a fashion that is unambiguous.
>
> The voltage baseline had to be as expected in North America, being 120V +/- 4%, 60 Hz.
>
> **Within the engineering design of the system observed, everything can be turned on, without affecting the supply voltage of 120V by more than about 3%.**



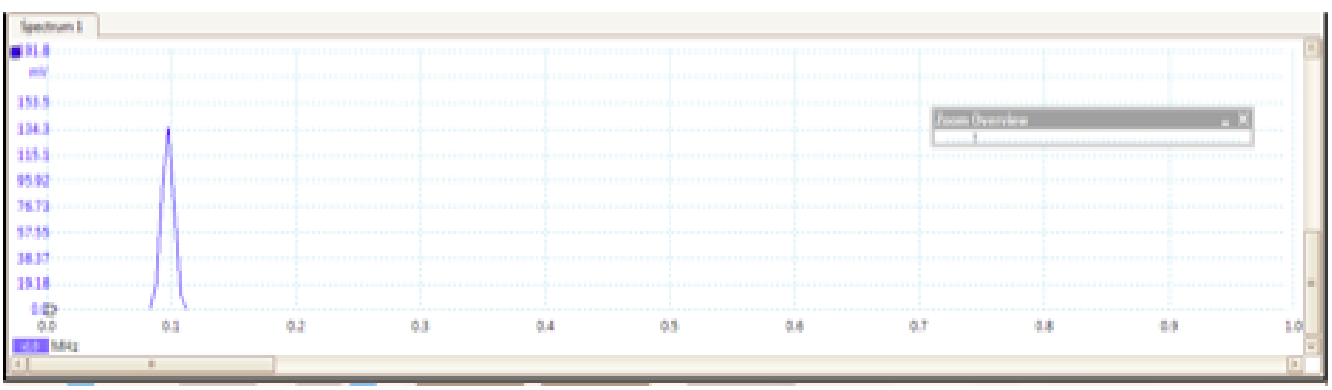
I began with a Picoscope (*an inexpensive computer-driven oscilloscope / spectrum analyzer*) capable to 5 MHz, and used an external signal generator to feed it a 100kHz sine wave at about 100 mV. The time base per cycle would be 1/100,000 = 10 microseconds, or 10µs, as shown above, which is a satisfactory display, being 200 ms left to right = 20 cycles.



However the spectrum analyzer Vertical setting was Logarithmic as above, revealing the device’s internal noise, which was not desirable. So I set the spectrum analyzer Vertical to Linear, which removed the internal noise and cleanly provided the signal being generated by my previous setting, as shown above with clutter, and below.

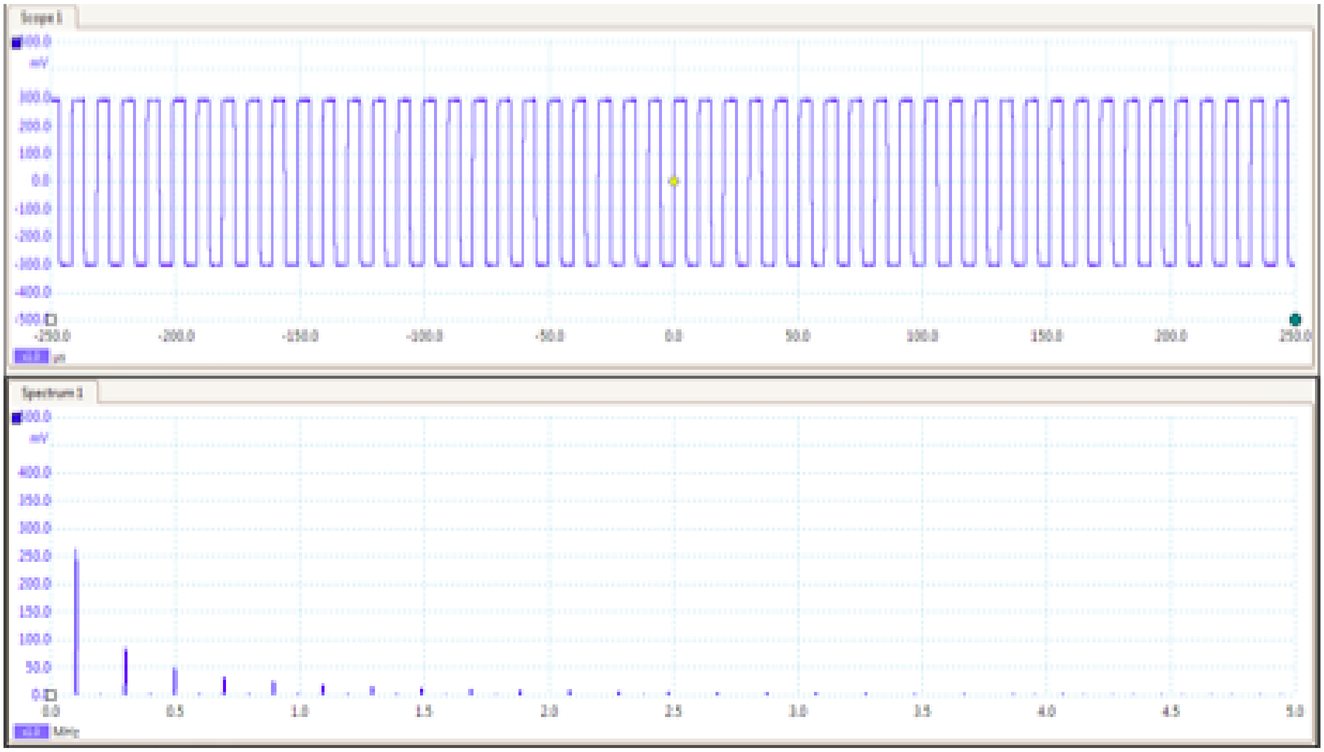


As shown, the 100 KHz was located where I expected it, relative to the full scan of 5 MHz, so I almost deemed that acceptable. But wanting to verify I was actually seeing the injected 100 kHz, I zoomed in horizontally (*frequency-wise*) to 1MHz, and seeing nothing but the intended signal as below (*0.1 MHz = 100 kHz*),



I deemed that acceptable.

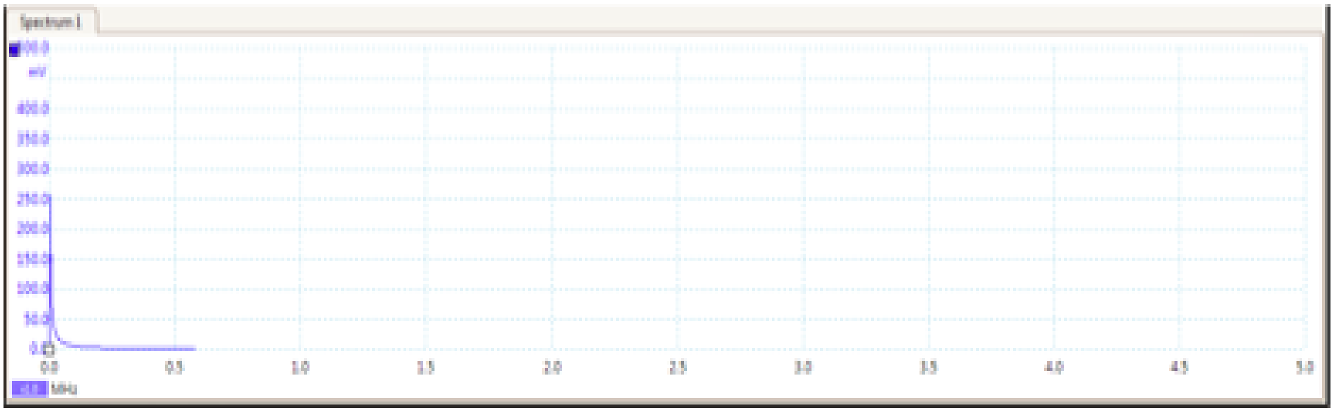
I then switched the input to a Square wave, bumped up the amplitude to about 300 mV, zoomed out to 5 MHz and acquired the graphs below. The waveform and spectrum displays were acceptable as the square wave was clean.



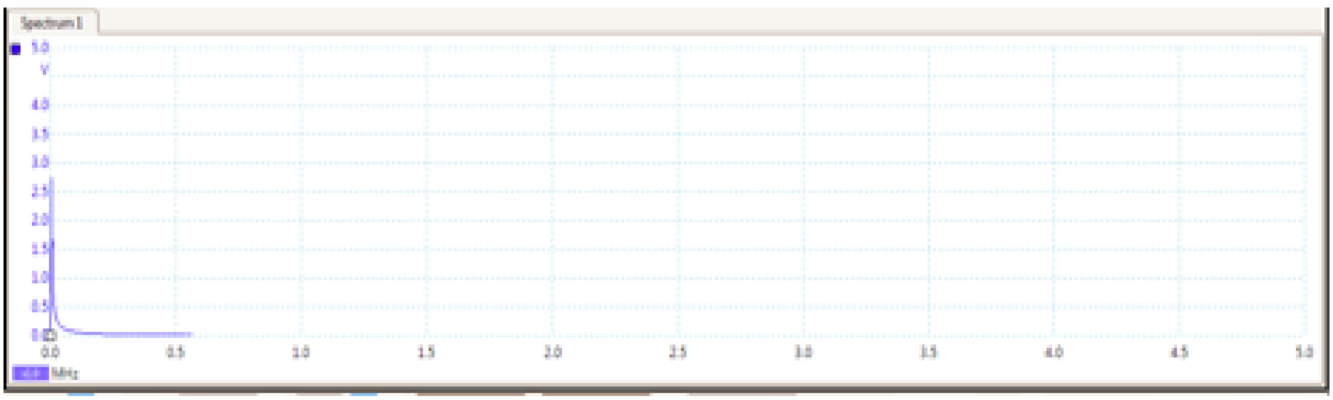
I zoomed in vertically (*intensity-wise*) on the spectrum display to verify Harmonic frequencies, and only the Odd Harmonic multiples of the Fundamental (100 kHz) were displayed, as should be expected of a wave that is symmetrical about its midline. That is, equal distance traveled above the zero voltage reference, as below it. Verify this by viewing the above waveform at 300 mV above, and 300 mV below, zero.

If symmetry about the midline is lacking, Odd <u>and</u> Even Harmonics are displayed. The harmonics shown are 300 kHz, 500 kHz, 700 kHz, etc. or only Odd ones, shown as 0.1 MHz, 0.3 MHz, 0.5 MHz, 0.7 MHz, etc.

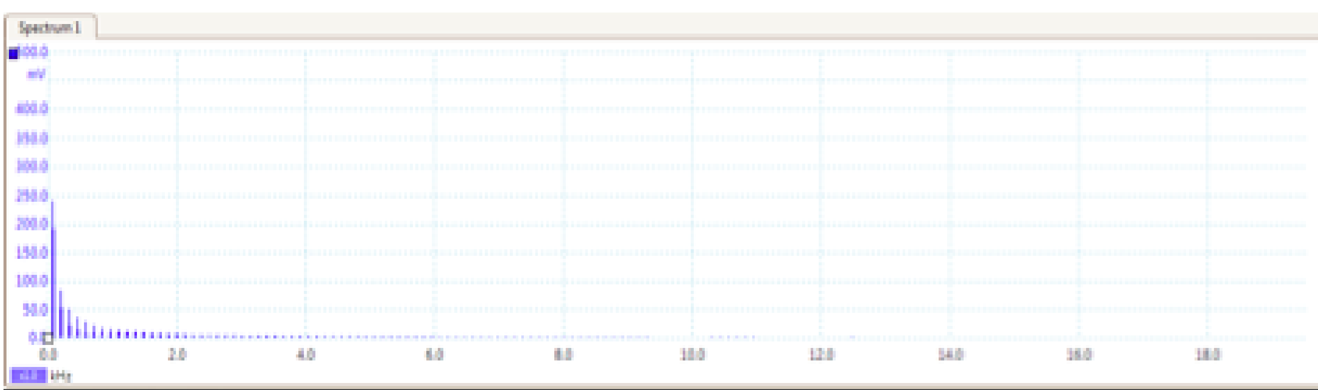
I then changed the external oscillator to 64 Hz, and kept the square wave, resulting in the spectrum below.



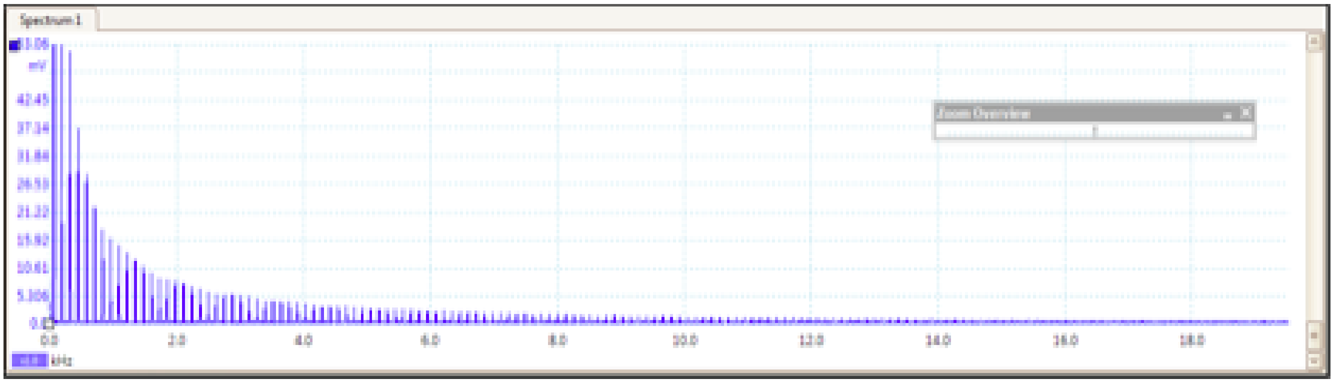
I then changed the amplitude of the square wave from 100 mV to 3V, resulting in the spectrum below.



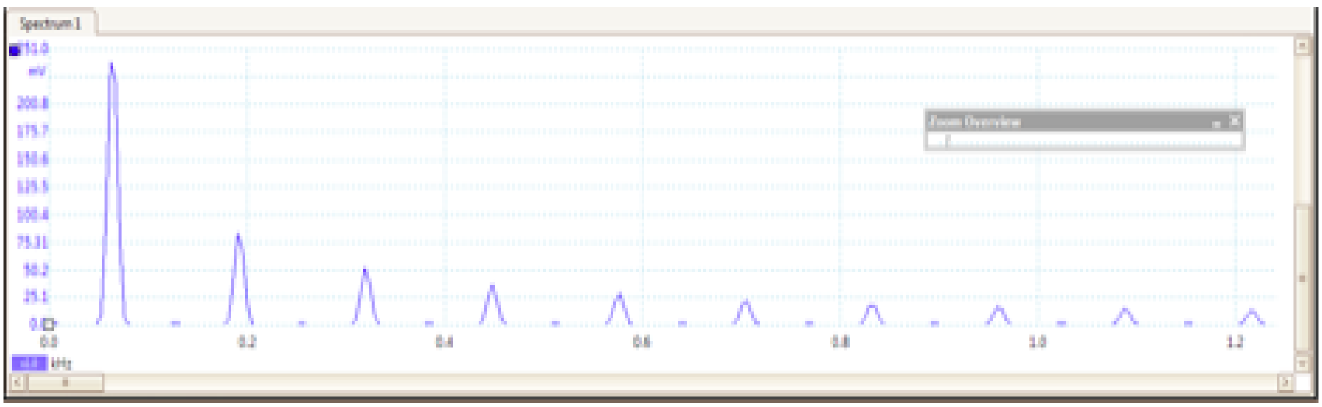
It might appear that all relevant activity is happening exclusively below about 0.5 MHz / 500 kHz. I reset the input to 300 mV. I progressively zoomed in horizontally (*frequency-wise*) for detail, and as I did, the displayed detail remained about the same until I zoomed down to 20 kHz, achieving the spectrum display below.



I then zoomed in vertically to view the strongest harmonics.

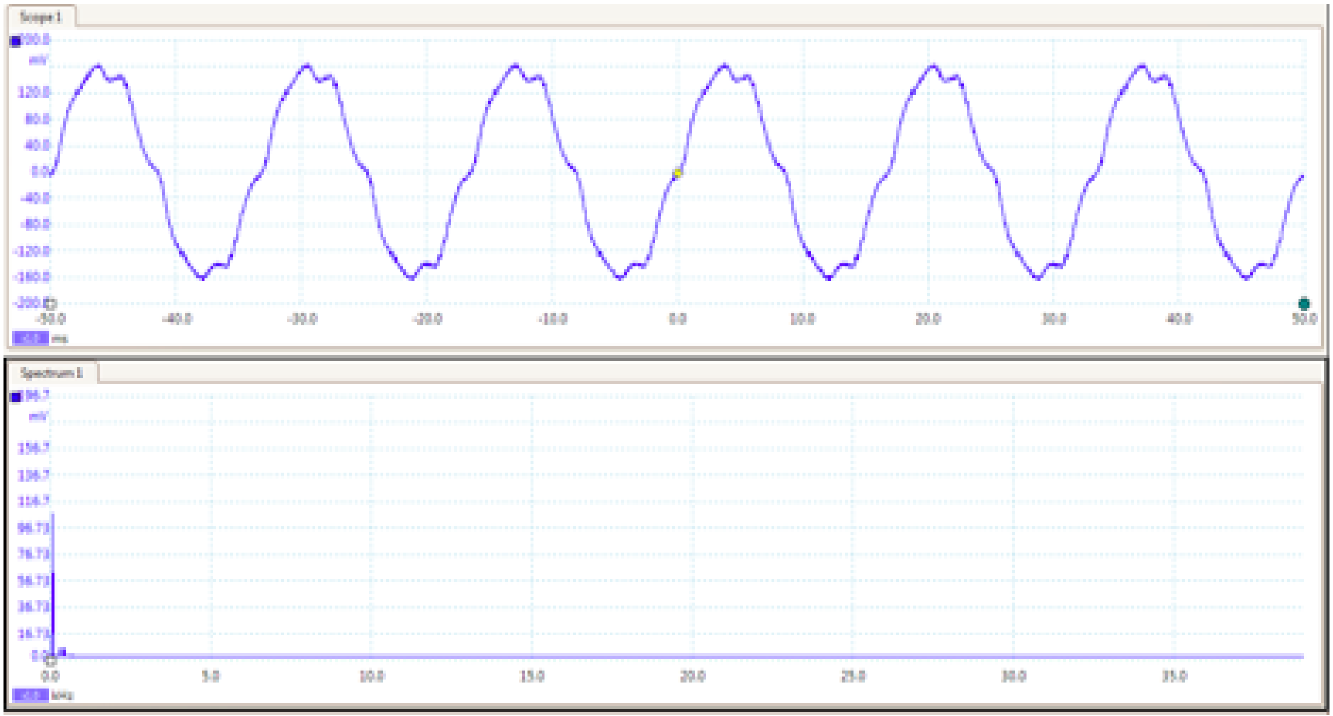


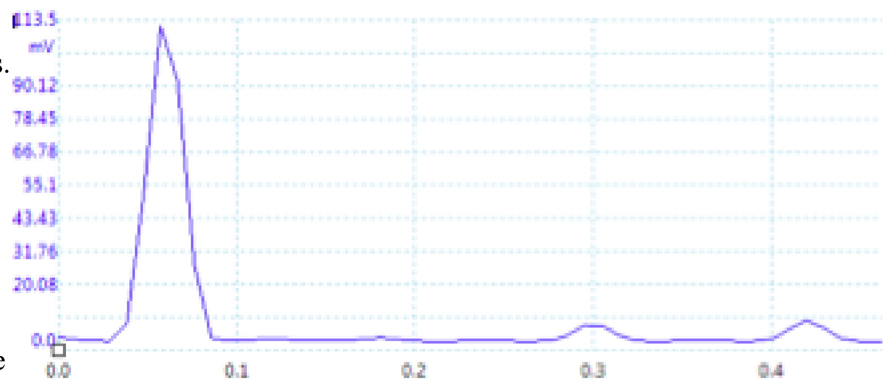
To verify the injected signal frequency of 64 Hz, the Fundamental, and the first bunch of harmonics, I zoomed in horizontally. As shown below, they would 64 Hz, 64x3 (192), 64x5 (320), 64x7, 64x9, etc.



I now felt I could use the instrument to look at the power system.

I connected to the 120V, acquiring the graphic below. *Caution: the Picoscope's rated maximum input is 30V, so direct connection is not possible.*

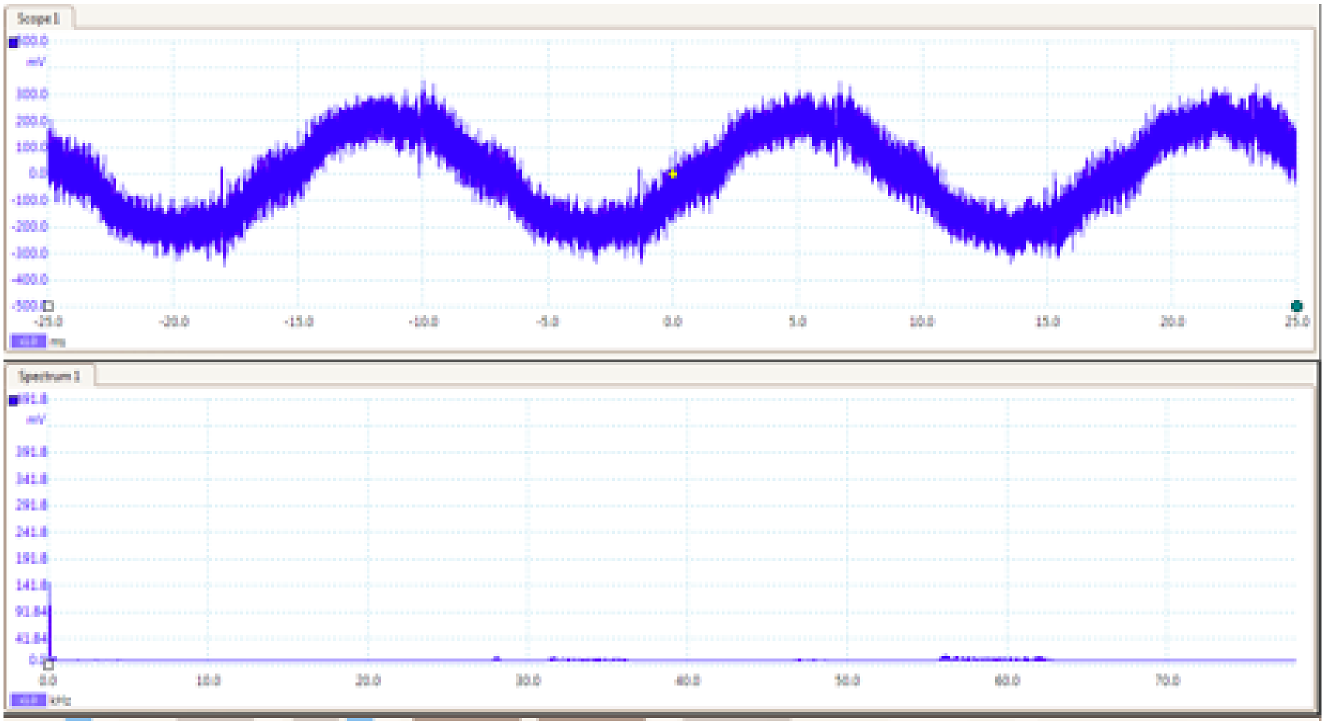




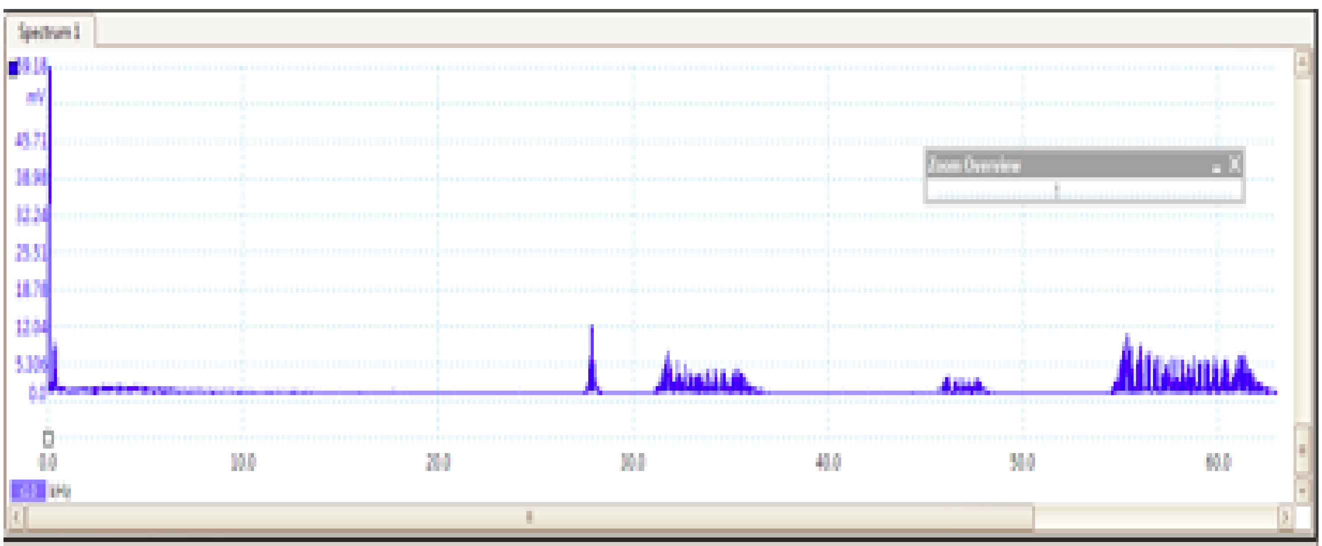
In the display at right I was interested in a little more detail of the harmonics.

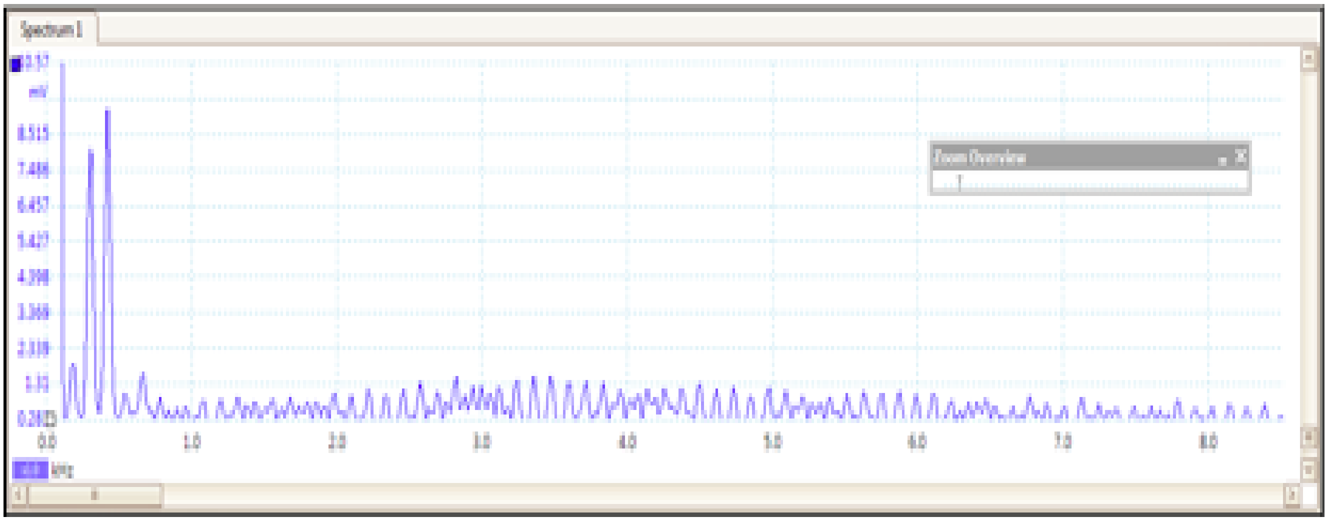
I zoomed in to get detail (*perhaps excessively, the frequencies can be displayed more accurately, but I was simply concerned for presence, not elegance*) and noted 60 Hz, 300 Hz, and 420 Hz, shown as 0.06, 0.3, and 0.42 kHz respectively. I also noted the 300 and 420 Hz harmonics a bit short of 10 mV, while the fundamental is about 110 mV, so the waveform harmonic distortion is below 10%.

I powered up several CFLs from different vendors totaling about 860 mA, and captured the graph below, to 70 kHz.



I zoomed in vertically to get slightly better detail, and acquired the spectrum below.





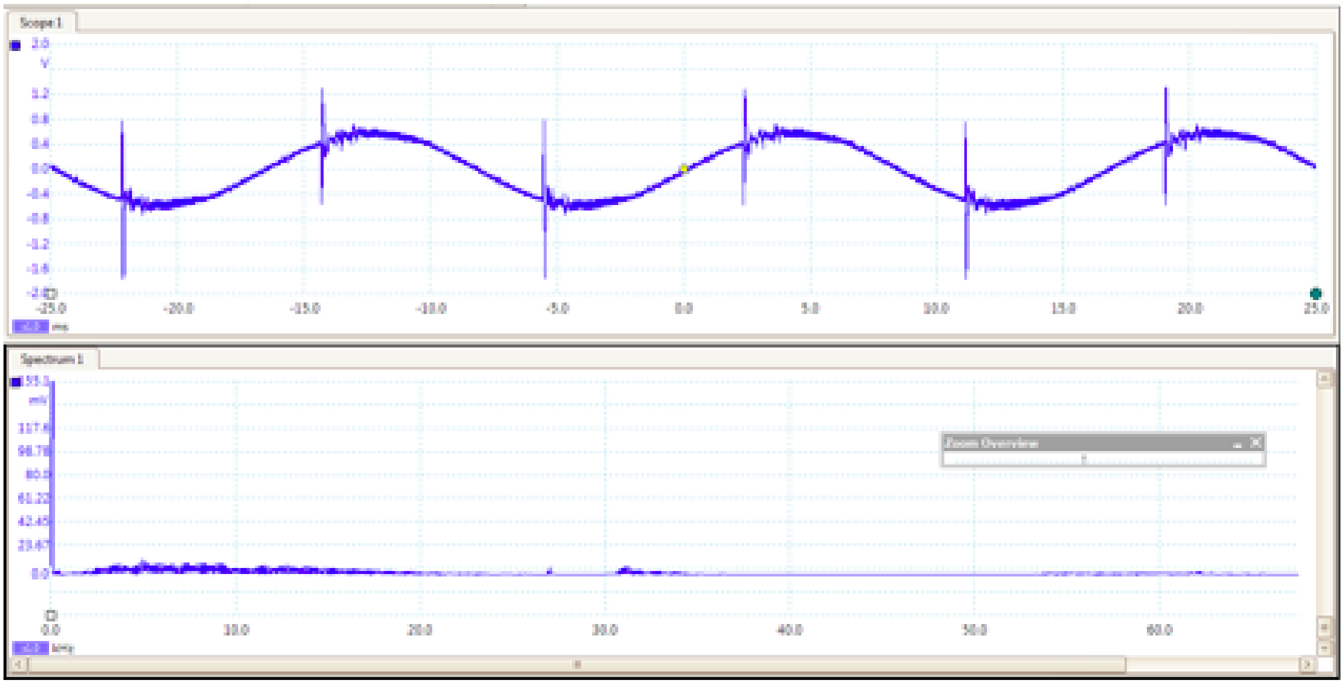
While lower in the audio range, I saw the above, to about 9 kHz. The lowest peak to the extreme left, extending beyond the top of the graph is the 60 Hz, then 180, then the next two high peaks of 300 and 420, 540, 660, etc.

I powered down the CFLs, and plugged in a DE meter that read about 70. I turned on the CFLs once more. The DE meter now read 570, as expected. I plugged in a DE "filter." The DE meter dropped to about 50, as expected. **However, the display showing harmonic content, remained unchanged.**

I connected the Picoscope through a "ubiquitous DE filter," hereinafter the "*ubi*,"and detected 0.4VAC with an RMS voltmeter (*supposedly representing an aggregate of fast frequencies, the electrical "dirt"*), and 0.8 VAC Peak with the Picoscope, except for the digital spikes.

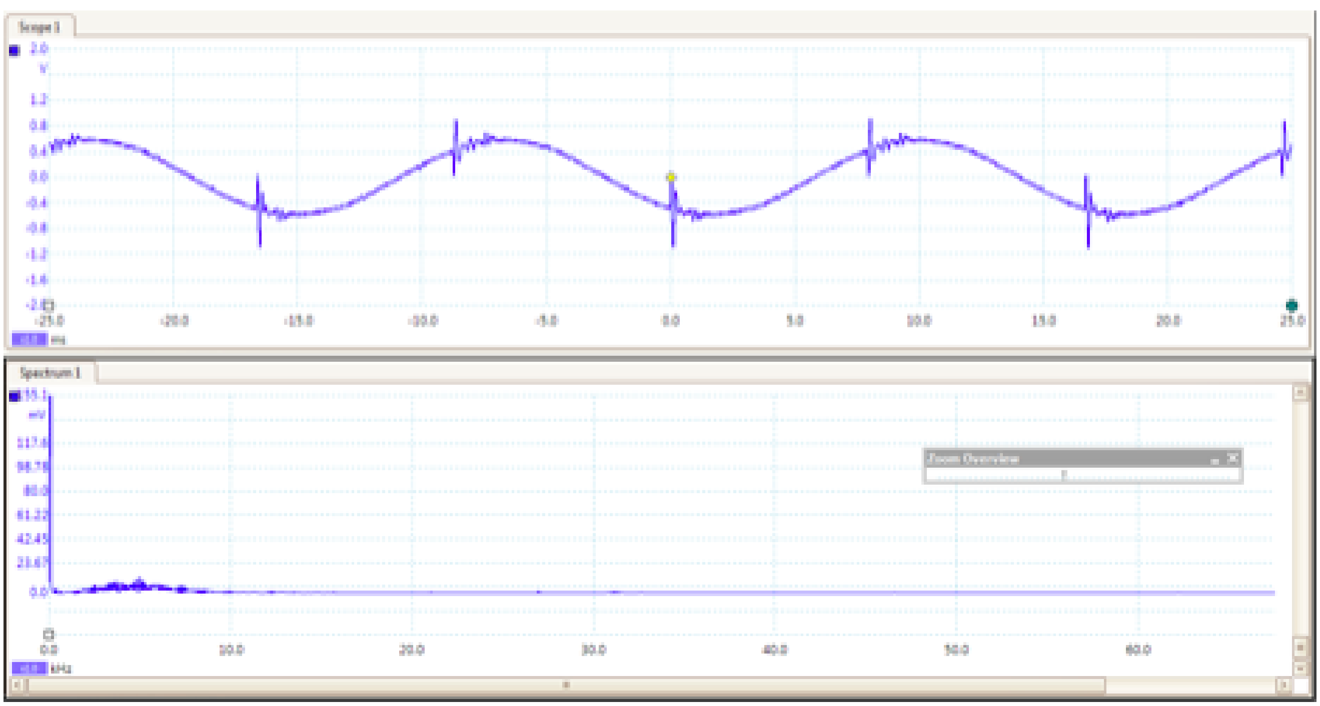
> *I momentarily connected the PC to AC power for charging, but the difference between the charger's frame of reference through the Picoscope, and hard contact to the "ubi" filter output (*which is supposed to be small*), expressed 40 V or more potential difference, causing the Picoscope to display a top-and-bottom-clipped sine wave (*looked like a full-scale square wave*), and warning of input overload. Not being nice to your instruments can ruin your day . . .*

The waveform and spectrum through the "ubi" filter, with the PC on battery to 70 kHz, with the CFLs on, is below.



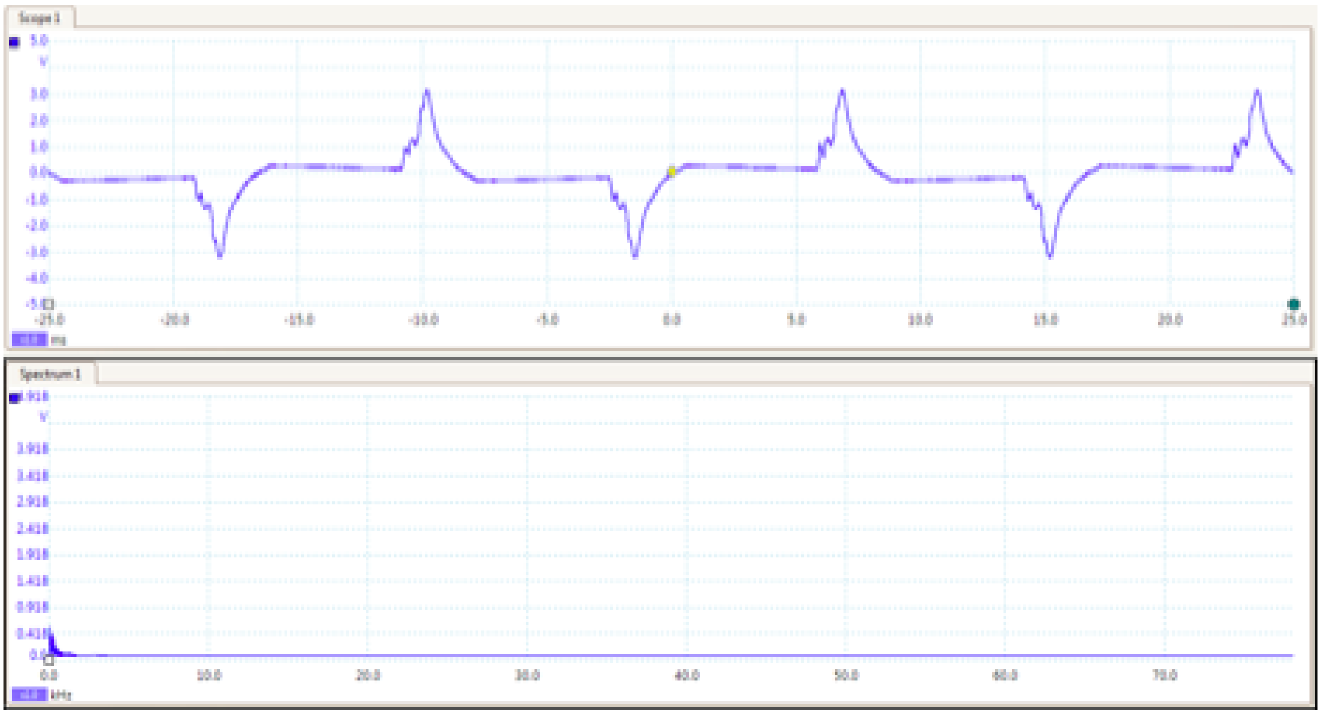
Compare the “ubi” filtered spectrum above, with the unaltered one on the bottom of page 5. Also compare the “ubi” filtered waveform above, with the unaltered on the middle of page 5.

The waveform and spectrum, through the “ubi” filter, <u>with the CFLs on, AND a DE filter,</u> is below.

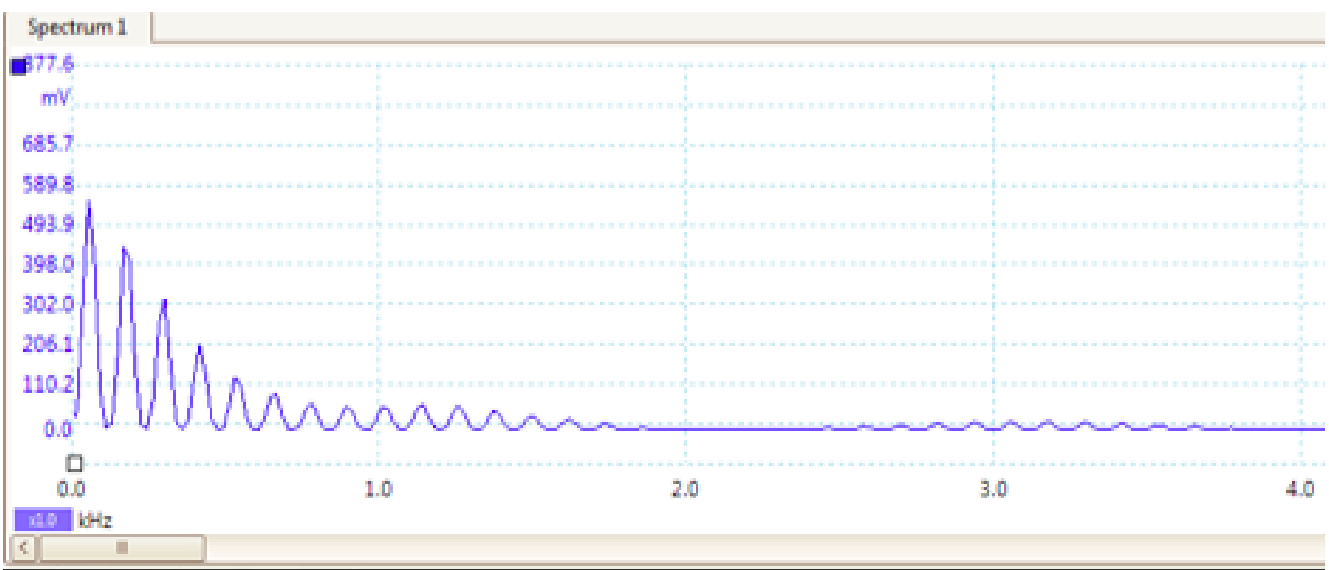


Lots of change, heh? You are left to guess how the “ubi” filter is “massaging” your data. From the experiences I have of safely operating a nuclear power plant, and a bulk power transmission systems, I've had the necessity to properly assess electrical signals of various origin, in order to employ appropriate corrective measures, to maintain system integrity (*but please, don't let appearances deceived you*). I thus fail to appreciate what the "ubi" filter does, other than maybe slick marketing . . .

While all the previous graphs considered Voltage only, I then looked at the Current of the CFLs, as below.

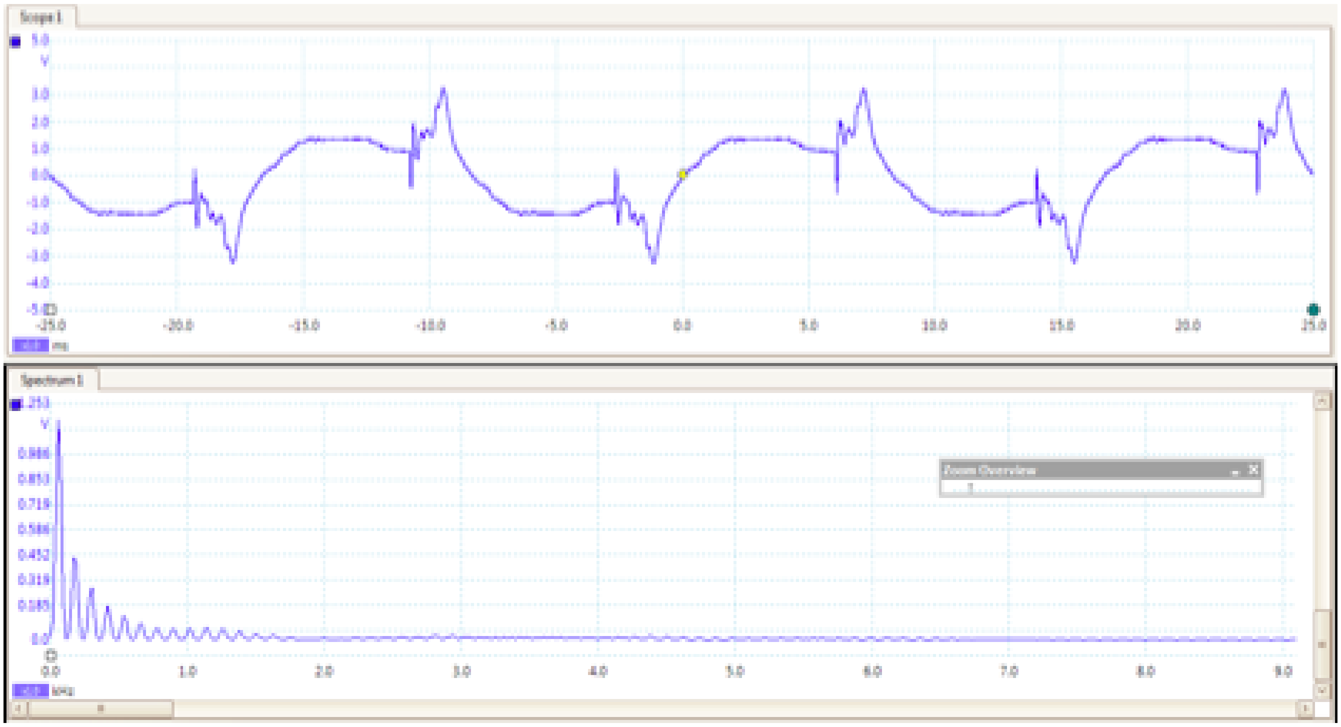


With a slight zoom on the low end of the harmonics below. Shown are 60, 180, 300, 420, etc.



Waveform Harmonic distortion from a smooth 60 Hz sine wave, about 80%.

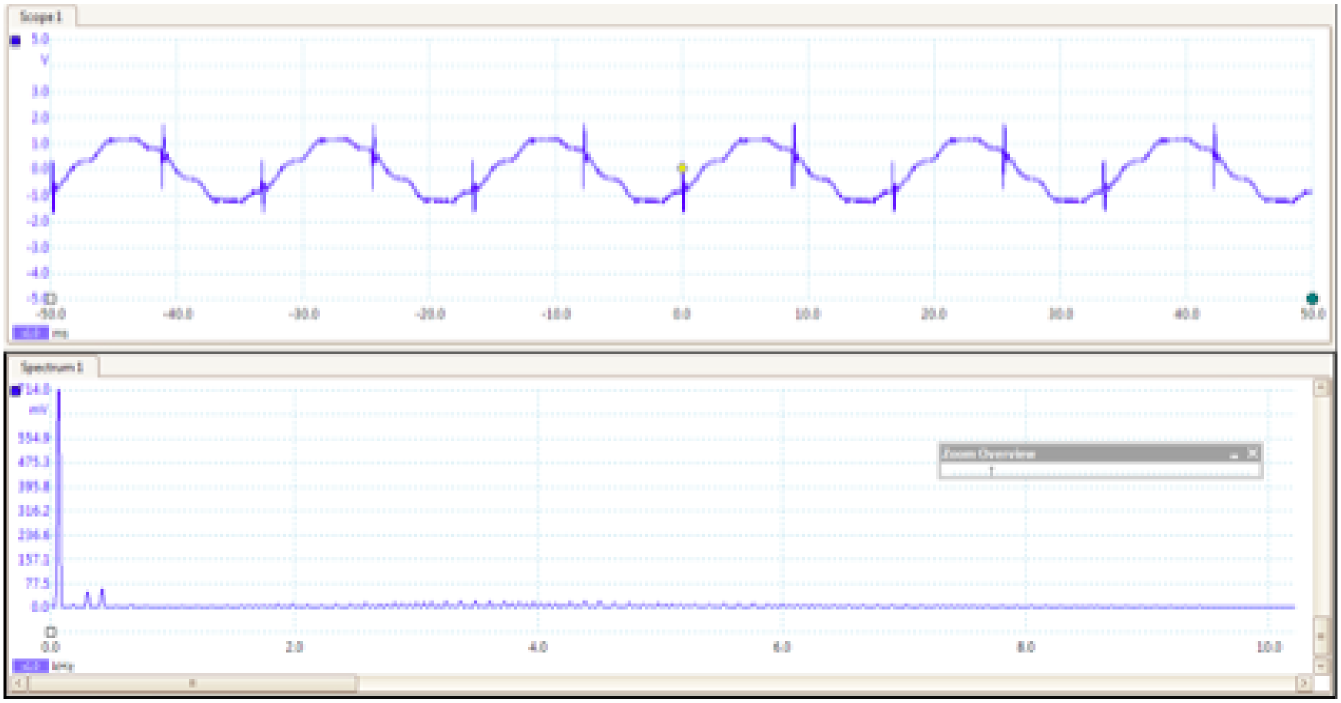
I then plugged in a DE filter, and noted the waveform and spectrum below.



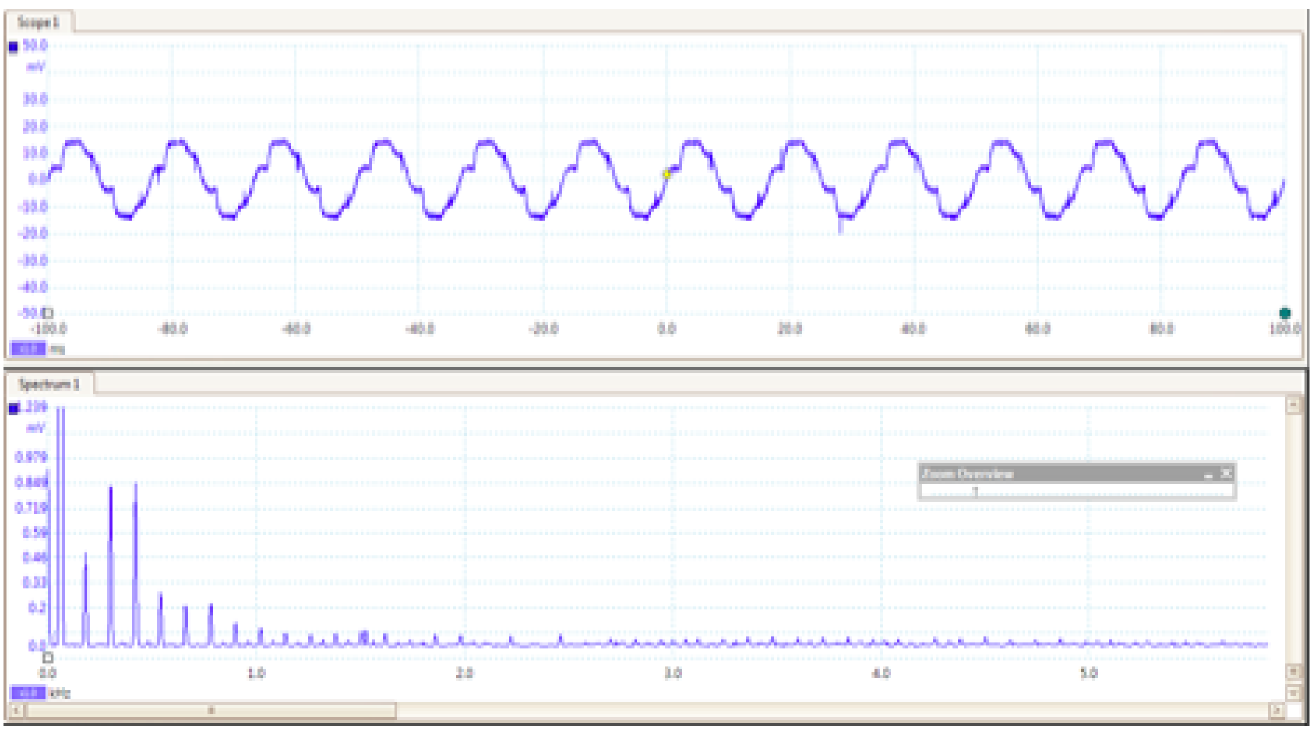
Waveform distortion from 60 Hz sine, about 45%. Note that the harmonic frequencies present in the previous graph are still there, at about the same amplitude (*which should make you wonder*). However, due to the now greater 60 Hz current demand, in perspective they might appear less "relevant."

> Voltage measurement "in circuit" as done here, is quite different than Electric field measurement in free space, except for emphasis of harmonics due to different polarity buses in the latter, where the 60 Hz displays apparent cancellation. But the same sensor can be used for both.
>
> Current measurement in circuit as done here, is little different from magnetic field measurement in free space. The same sensor can be used for both.

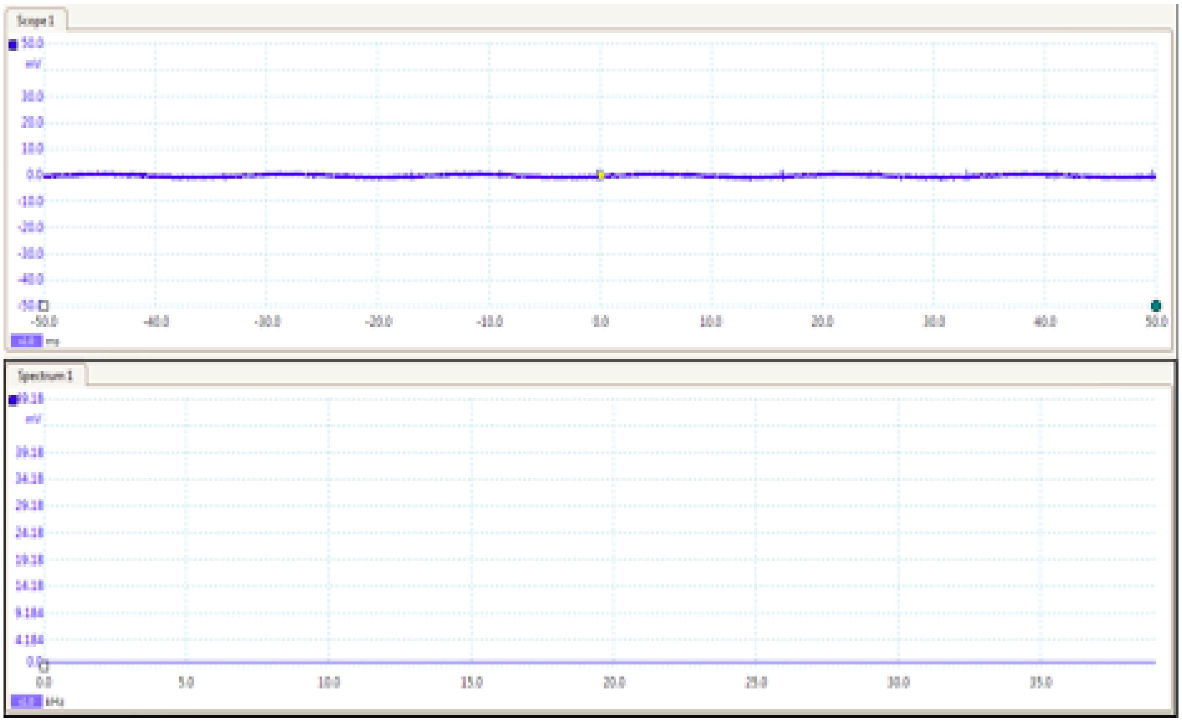
I then turned off the CFLs, and looked at the current used by the DE filter, and DE meter, below.



I then looked at the current used by the DE meter only, after zooming in a bit, below

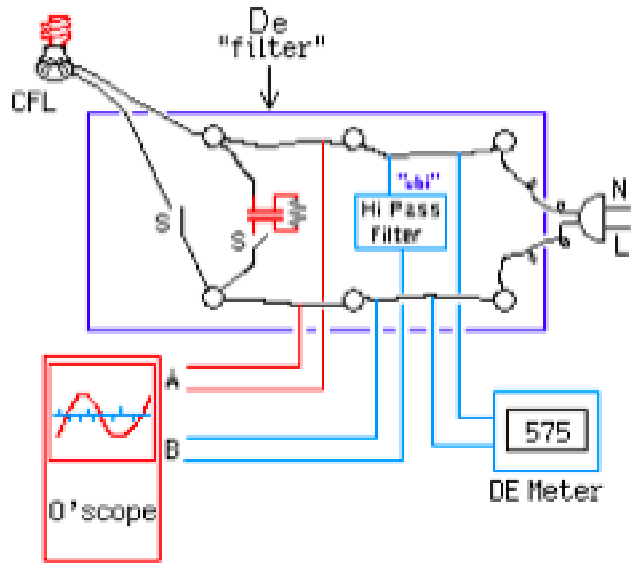


I then unplugged all Current users, and was left with the Picoscope flatlining, below.



The Windows PC has a touchpad with a sensing frequency of about 51kHz. Depending on the bandwidth limits, this can present itself as a phantom noise source around 26 kHz, but only if the touchpad is in use.

The methodology for measuring power system harmonics has long been established. Its constraints are strictly imposed on industry to prevent compromising the power quality for other users at large. While the "dirty electricity" phenomenon is recent, perhaps 20 years, several vendors have joined the money train. Yet the electrical "dirt" has been present on most electric systems to some degree since electricity has been available, more than 100 years. The nonstandard, but popularized, arrangement is shown below.



In this arrangement, an oscilloscope is connected directly to the 120V to acquire the sine waveform (*the red trace on the simulated o-scope screen below*). Another input is connected to the o'scope second channel, this being the output of a ubiquitous (*slick naming, eh?*) / "ubi" filter to block most frequencies below about 4 kHz. Somehow, this second channel (*the blue trace*) is supposed to represent an aggregate of the higher frequency content, but gives no specific frequency information. The "ubi" filter is also integrated into a separate plug-in meter.

What I attempt to show here, is that with reasonably inexpensive instruments (*and without the popularized test scheme and tools shown above*) you can get an immediate and complete visual display, giving exact frequency information. No guessing involved, and no "ubi" filter to distort measurement needed.

Yet some consultants (*building biologists, geo-biologists, and engineers even*) proceed to measure various outlets with a DE meter, and promote filter installation as a panacea that will make your home electrically "clean." I feel bad for their clients, who are misled by a marketing scheme, and for the consultants because they know no different, and once certified cannot be "re-educated," but I feel angry for their instructors, who should be thrown out into the streets to look for a job to match their talents (*or rather lack thereof*).

Filters "cleaning" electricity, could not be further from the truth (*and in many cases it will make conditions worse*).

But, of course, this is only my opinion . . . (*and that of my clients*).

<u>Some conclusions:</u>

1) **If the Voltage has harmonic content to begin with, linear current users, such as incandescent lamps, will have the same harmonics in their Current.**

2) If pre-conditions # 1 and # 2 listed previously are not met, these will need to be resolved, as free space magnetic field testing may not replicate circuit testing described here. Considering that current / magnetic field distortion can / will be >100%, should make you think twice, before purchasing a meter not RMS compliant.

3) With no a) wiring errors, b) external power line fields, and c) no relevant levels of stray current through systems grounded together, magnetic fields will not exist except immediately near cabling, so ambient magnetic field measurement is unnecessary and irrelevant.

3) If there are magnetic fields *(excluding those from external power lines*) the harmonics content will be a much more significant portion of the field. This has strong implications for Gaussmeters that do not measure the fields with RMS constraints (*such as the Trifield*), as they may display a value as much as 50x the real field. These fields can be eliminated.

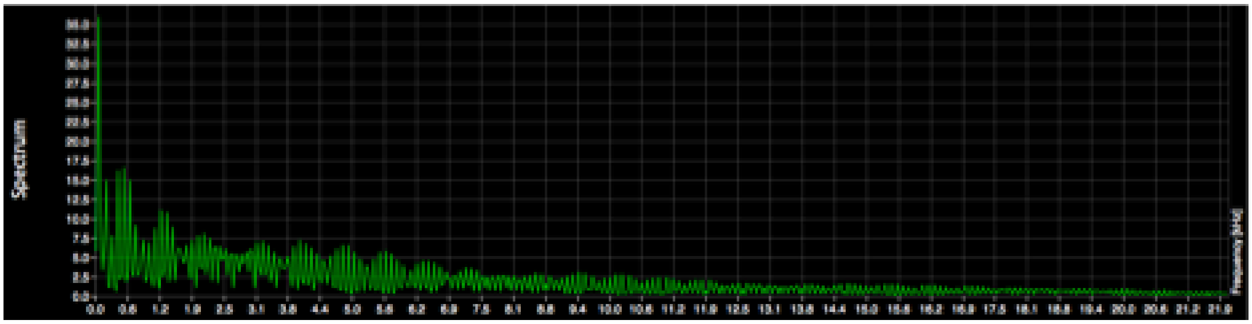
4) The character of harmonics should be similar in all cases. That is, the Fundamental, or source frequency, is always there, and its "echoes" will progressively get smaller as the frequency increases, or should, unless there is some resonance process occurring. **Frequencies higher than audio (*to 20 kHz*) are usually "dust" relative to the harmonics in the audio range, and more specifically the range used for speech. That is, less than 5 kHz.**

5) The use of a "ubi" filter gives a false sense of no relevant harmonics where they are the strongest, and which are the most biologically relevant. But what the "dirty electricity" group are promoting, is those harmonics slower than 4 kHz don't matter. You can decide on your own why this is.

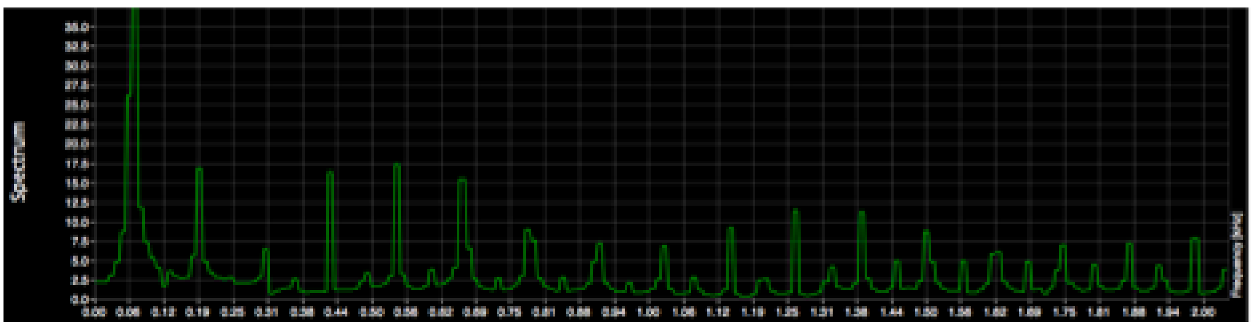
While I was amused toying with a Picoscope, there is a much simpler, and less expensive means of screening for harmonic content.

And as a hint of that, due to my generosity, enclosed are:

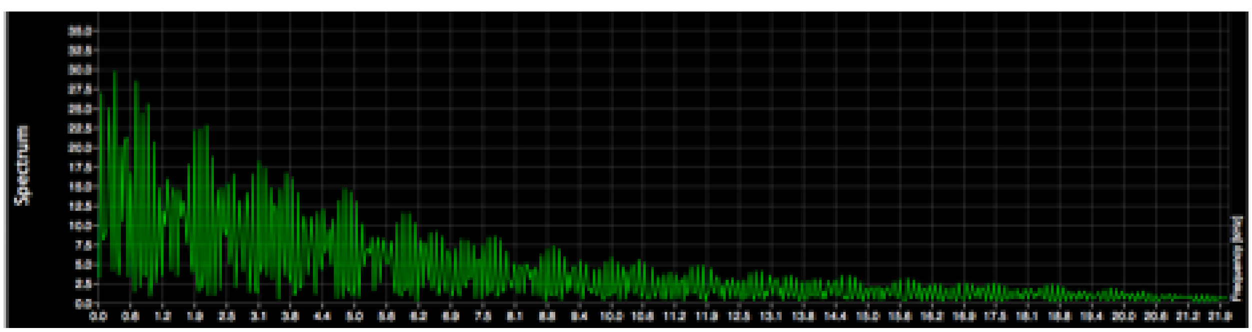
The current spectrum through a dimmer, on maximum intensity. The leftmost peak is 60 Hz.



The current spectrum through a dimmer, on maximum intensity, zoomed in. The leftmost peak is 60 Hz.

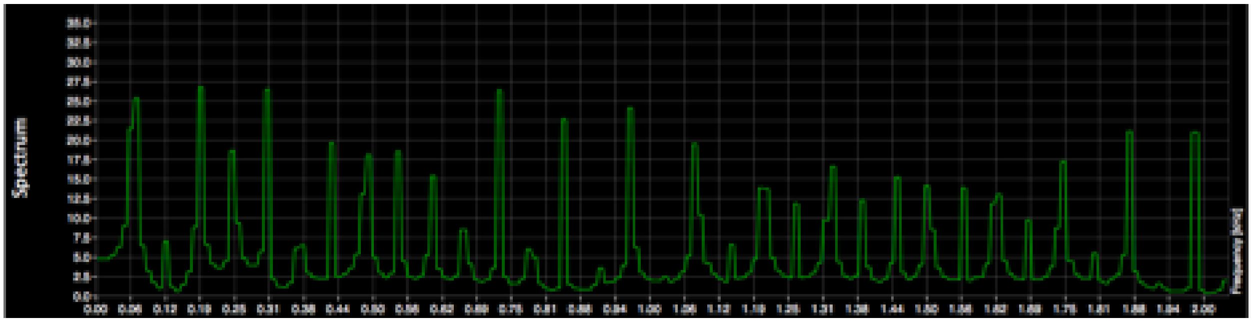


The current spectrum through a dimmer, on minimum intensity. The leftmost peak is 60 Hz.



The leftmost peak is 60 Hz, and while still present, the harmonics match the intensity of it. This is “mood” lighting, which easily drives some people up the wall, if allowed in free space. While there is a premise that you can turn on everything, and still have 120V (*240V in international markets*) or close to it, introduce enough of these, and you have an “unexplained” RF presence because the Harmonics will extend well into the genuine RF spectrum. Neither the DE metering, or their scope setup will see this.

The current spectrum through a dimmer, on minimum intensity, below, zoomed in.



Assessment inquiries welcome.

Measurement tutoring, at the going rate.

Questionable (*Deceptive?*) Marketing

There is a type of wire installed in most floors, walls and ceilings that produces electric fields beyond its insulating jacket. Plugged-in power cords enhance this effect. In and of itself this is a pervasive and persistent biological irritant, and possibly a causative agent of disease. It is associated with a peak in childhood leukemia between the ages of 2 and 4. So if all variables line up . . .

But if they don't, related consequences? Yes, but "unidentifiable" as to their cause by classical medical practitioners, because we needs millions of bodies to "prove" the point. Whose "body" are you willing to sacrifice?

To complement this nightmare, there is the matter of non-linear power use that causes electrical distortion. That is, feed it a smooth 60 Hz (*/50 Hz*) Voltage, and the result is a Current, quite unlike the input, barely recognizable. This distortion consists of echoes of 60 (*/50 Hz*) Hz, aka Harmonics, produced by dimmers, fluorescents, digital devices, etc. A small portion of these harmonics will be present on the wiring mentioned above, and be detectable throughout all living spaces. Harmonics are central nervous system irritants, and the physiological reactions are legion.

The most powerful harmonics are in the audio range, and within the portion of that range (*used for speech*) that we are most sensitive to. Due to a subtle physics phenomenon, these harmonics and electric fields will also be present **within** the human body exposed to them.

Magnetic fields, when present, are much worse than electric fields, since their HD / Harmonic Distortion is usually much worse than voltage / electric fields.

Arrive the miracle cures . . .

Some people claiming technical expertise are marketing filters to “clean” your “dirty electricity / DE” (*simply a marketing term for Harmonics*). Some of the related names are Mircosurges, Microsurge Electrical Pollution / MEP, Transients, etc. Copycat gimmicks are “harmonizers,” “balancers,” etc.

What is most deplorable is that an institution or two that claim to be helpful to all have bought into this marketing. Some of its adherents, even electrical engineers, have bought into the DE mantra lock, stock, and barrel, and are making a group of possibly great environmental experts act like a bunch of novice boy scouts (*no offense to the real Boy Scouts*). That is, with the rare exception of a few I’ve mentored.

To correct this great injustice, you the average Joe, or Jane (*or as an upgrade to those that claim building biology credentials*) need to be educated / re-educated, easily accomplished by structured learning and tutoring, to be able to tell the difference between real consultants and hucksters, and change your life (*or that of your clients, if you are a consultant*) for the better.

While this may seem far fetched, taken one small morsel at a time, anyone can accomplish this.

Should you be interested, please contact me at (574) 935-0870 or eainc@emfrelief.com