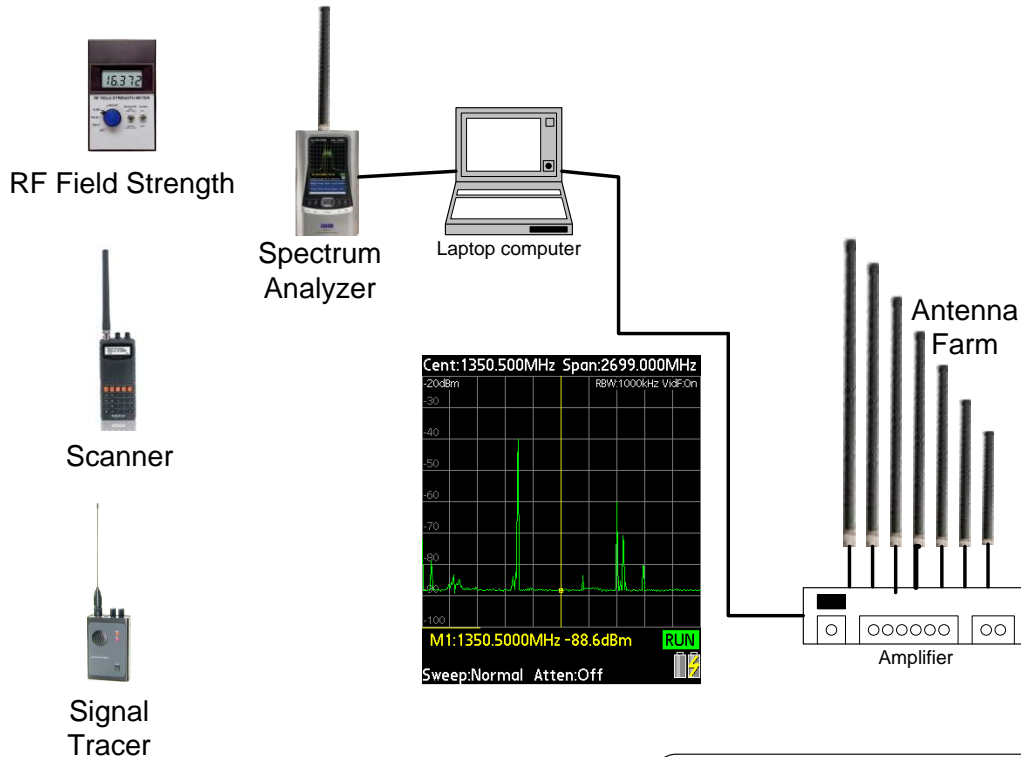


Radio Frequency Monitoring



S.P.I.R.I.T.		
RF Console	5/4/2010	D. Rountree

Radio Frequency Monitoring Console

By far the most troublesome phenomenon we encounter in the field isn't paranormal at all, but is often misread as such. Radio Frequency Interference or RFI is often the cause of EVPs, and can in some circumstances be the cause of EMF spikes in the higher frequency spectrum.

Radio waves are everywhere. We are constantly being bombarded with Microwave from satellites in space and Communication towers, Ultra UHF from Cell phone towers and the phones themselves, Public Service Radio systems (Police, Fire, etc.) Wi-Fi networks for wireless internet, cordless phones, walkie talkies, you name it. RF is everywhere. So with all this noise out there, how can one separate the wheat from the chafe?

Electromagnetic interference (or EMI, also called radio frequency interference or RFI) is an undesirable disturbance that affects an electrical circuit due to electromagnetic radiation emitted from an external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the effective performance of the circuit. The source may be any object, artificial or natural, that carries rapidly

changing electrical currents, such as an electrical circuit, the Sun or the Northern Lights.

EMI can be induced intentionally for radio jamming, as in some forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses, intermodulation products, and the like. It frequently affects the reception of AM radio in urban areas. It can also affect cell phone, FM radio and television reception, although to a lesser extent. *It can also effect complex test instruments used in paranormal research.*

EMI or RFI may be broadly categorized into two types; narrowband and broadband.

Narrowband interference usually arises from intentional transmissions such as radio and TV stations, pager transmitters, cell phones, etc. Broadband interference usually comes from incidental radio frequency emitters. These include electric power transmission lines, electric motors, thermostats, bug zappers, etc. Anywhere electrical power is being turned off and on rapidly is a potential source. The spectra of these sources generally resembles that of synchrotron sources, stronger at low frequencies and diminishing at higher frequencies, though this noise is often modulated, or varied, by the creating device in some way. Included in this category are computers and other digital equipment as well as televisions. The rich harmonic content of these devices means that they can interfere over a very broad spectrum. Characteristic of broadband RFI is an inability to filter it effectively once it has entered the receiver chain.

Power line noise

Virtually all power-line noise originating from utility company equipment is caused by a spark or arcing across some power-line related hardware. A breakdown and ionization of air occurs, and current flows between two conductors in a gap. The gap may be caused by broken or loose hardware such as a cracked insulator. Typical culprits include inadequate hardware spacing such as a gap between a ground wire and a staple. Once an ionized path is established in the gap, current flows at all parts of the cycle where the voltage is higher than the breakdown voltage of the gap. This typically occurs only at the positive and negative voltage peaks -- the times of highest instantaneous voltage throughout the cycle.

As an example for a 60Hz system (i.e. power-lines carrying 60 Hz AC, such as in the US), the voltage passes through two peaks each cycle (one positive and one negative) and pass through zero twice each cycle. This gives 120 peaks and 120 zero crossings in each second (50Hz: 100 peaks and crossings correspondingly). Power-line noise follows this pattern, generally occurring in bursts at a rate of 120 bursts per second. This gives power-line noise a characteristic sound that is often described as a harsh and raspy hum or buzz. Because the peaks occur

twice per cycle, true power-line noise has a strong 120-Hz modulation on the signal (50Hz system: 100Hz).

Lightning, the Mother of all Spikes, radiates radio energy across all bands from VLF to microwaves. Other weather conditions, known as spherics, also generate significant energy which often results in small electrical discharges, generating Radio Frequency Interference. While not as severe or dramatic as lightning, serious communication interference can result.

RFI can also be the source of EVPs. This is why you can place no stock into the gimmicky magical electronic devices that claim to communicate with the dead. These devices use randomly tuning AM radio receiver integrated circuits which catch bits and pieces of voice from broadcasts. They are also completely unshielded, so if the input to the IF section is detuned, the bandwidth of the receiver broadens to pick up a great deal of garbage. Then there are the harmonics that get involved, trust me, it's a mess. Consequently, there is virtually no way to determine whether you are hearing your dead relative or a Ham operator with a sense of humor. And if someone is telling you different, it is most likely because you have given him money to do so.

Consequently, when debunking your EVPs you MUST remove RFI as a possible cause of the phenomena. Any EVP recorded in conjunction with a radio transmission is subject to question, therefore must be eliminated as plausible evidence. If it can be readily debunked, it isn't strong evidence. This console set up is designed to monitor as much of the RF spectrum as possible and document the activity in real time, for comparison to other readings and recordings.

As always, anything that can not be monitored electronically as real time data is monitored in real time on video cameras. Monitor, trace to a source, identify and eliminate. Only by doing this can you end up with something that is truly outside the norm, and paranormal in nature. Now for a breakdown of what we use:

Scanners



A scanner is a radio receiver that can automatically tune, or scan, two or more discrete frequencies, stopping when it finds a signal on one of them and then continuing to scan other frequencies when the initial transmission ceases. The terms radio scanner or police scanner generally refer to a communications receiver that is primarily intended for monitoring VHF and UHF land mobile radio systems, as opposed to, say, a receiver used to monitor international shortwave transmissions.

More often than not, these scanners can also tune to different types of modulation as well (AM, FM, WFM, etc). Early scanners were slow, bulky, and expensive. Today, modern microprocessors have enabled scanners to store thousands of channels and monitor hundreds of channels per second. Recent models can follow trunked radio systems and decode APCO-P25 digital transmissions. Both hand held and desktop models are available. Scanners are often used to monitor police, fire and emergency medical services. Our scanner is sold by Radio Shack, and covers the most commonly used broadcast bands, VHF marine, fire/police, VHF aircraft, HAM radio, SAME or weather radio. While the scanner doesn't tell you much about signal strength, it does identify specific frequencies being used. This helps to identify and eliminate public service and other common bands from being a possible source of RFI. We deploy several of these scanners in order to monitor a wide band of RF activity.

Field Strength Meters



We use an RF Field Strength (technically a "power density") meter manufactured by Alpha Labs. We selected this device because it detects the electric field of

radio and microwaves (RF) from .5 MHz to 3 GHz, and expresses the field strength as power density (.001 to 2000 microwatts/cm²).

This is an extremely sensitive meter which can accurately measure RF background even in rural areas far from any transmitters. The meter reads true power density directly on the display. Unlike other low-cost field strength meters, this meter's frequency response does not depend on the characteristics of an external antenna; the internal detection system yields a flat response over a very wide range of frequencies.

Accuracy in the FM, TV and cell tower frequency range (30 MHz – 2.4 GHz) is +/- 25%. Sensitivity is low by 50% (-3 dB) at the frequency limits .5 MHz and 3 GHz. (Sensitivity is 25% at 5 GHz. That is, you must multiply the reading by 4 when measuring microwaves at that high a frequency. At 10 GHz, sensitivity is about 10%.)

A High-Pass selector switch allows you to measure either the full bandwidth ("Wide" = 0.5 MHz – 3 GHz) or to apply a high-pass filter ("Narrow" = 6 dB/octave rolloff with a knee at 100 MHz) that effectively allows only 100 MHz to 3 GHz through. In practice, this high-pass selector function can be used to estimate one additional parameter: the average frequency of the RF (if it is in the range 10 MHz – 500 MHz).

The RF Field Strength Meter is directional and it detects only the component of the electric field which has the same polarization as the long axis of the meter. That is, if only a vertically-polarized RF wave is present, but you turn the meter in the horizontal direction, it will essentially read zero. If you subsequently rotate the meter to vertical, it will then read the full power density of the RF wave. Most RF radiation has only vertical electric field, so the full strength can be read by holding the meter vertically. (At the end of this page is more information on how to read radio waves with other polarizations).

The meter has a 4 ½ digit display which reads in three ranges: .001 to 19.999, .01 to 199.99, and .1 to 1999.9 microwatts/cm². For comparison, a low power 100 milliwatt dipole transmitter (typical 49 MHz cordless phone) produces about .010 microwatts/cm² at a distance of 50 feet. This is 10x the minimum sensitivity of the meter. A FAST/SLOW update switch is normally set in the FAST position so you can quickly measure changes in the RF level. However, if the field strength is fluctuating rapidly, this switch can be set to the SLOW position, which averages the reading over several seconds.

The "zero" level will shift slightly with temperature. This shift is no more than +/- .010 microwatts/cm² over the meter's operating temperature range of 30° F to 110° F (-1 to 43° C). Two controls on the right side of the meter correct for this: a button, when pressed, turns off the pre-amplifier, so it is the equivalent of zero field. Then an offset control is rotated until the meter reads zero in the most

sensitive "19.999" setting. After one minute or more of warm-up, this should be adjusted. Once adjusted, this need not be readjusted unless the temperature changes by more than 5° F. (Then a shift of about .001microwatt /cm² will occur).

The RF Field Strength Meter comes with a standard 9-volt battery. A low-battery indicator shows on the display when approximately 10 minutes of battery life remain. Electric current consumption from the battery is about 15 ma, with low battery indication at about 7.6 volts.

RF Signal Tracer



Signal tracers are just that, devices you use to trace down the source of an RF signal. These devices are helpful in locating sources of RFI that may be in the person's home, and may be contributing to that "paranormal feeling". This device can trace down RFI from noisy electrical motors, appliances, and even WiFi networks. We deploy the **CS-RFT6002II** radio frequency tracer and have found it is the most useful of all the tracers we tested. It is hand held, can give a visual, audible or both notification upon detection of RF. It excels at silent detection of RF signals and is very popular in the intelligence community for locating wireless "bugs" and other eavesdropping/covert devices. Additionally, it has a frequency response of 1 MHz to 6GHz, which encompasses a very wide spectrum of detection.

RF Spectrum Analyzer



A spectrum analyzer or spectral analyzer is a device used to examine the spectral composition of some electrical, acoustic, or optical waveform. It may also measure the power spectrum.

There are analog and digital spectrum analyzers:

An analog spectrum analyzer uses either a variable band-pass filter whose mid-frequency is automatically tuned (shifted, swept) through the range of frequencies of which the spectrum is to be measured or a superheterodyne receiver where the local oscillator is swept through a range of frequencies.

A digital spectrum analyzer computes the discrete Fourier transform (DFT), a mathematical process that transforms a waveform into the components of its frequency spectrum.

Some spectrum analyzers (such as "real-time spectrum analyzers") use a hybrid technique where the incoming signal is first down-converted to a lower frequency using superheterodyne techniques and then analyzed using fast Fourier transformation (FFT) techniques.

Usually, a spectrum analyzer displays a power spectrum over a given frequency range, changing the display as the properties of the signal change. There is a trade-off between how quickly the display can be updated and the frequency resolution, which is for example relevant for distinguishing frequency components that are close together. With a digital spectrum analyzer, the frequency resolution is $\Delta\nu = 1 / T$, the inverse of the time T over which the waveform is measured and Fourier transformed (according to Uncertainty principle). With an analog spectrum analyzer, it is dependent on the bandwidth setting of the bandpass filter. However, an analog spectrum analyzer will not produce meaningful results if the filter bandwidth (in Hz) is smaller than the square root of the sweep speed (in Hz/s), which means that an analog spectrum analyzer can never beat a digital one in terms of frequency resolution for a given acquisition time. Choosing a wider bandpass filter will improve the signal-to-noise ratio at the expense of a decreased frequency resolution.

With Fourier transform analysis in a digital spectrum analyzer, it is necessary to sample the input signal with a sampling frequency ν_s that is at least twice the highest frequency that is present in the signal, due to the Nyquist limit. A Fourier transform will then produce a spectrum containing all frequencies from zero to $\nu_s / 2$. This can place considerable demands on the required analog-to-digital converter and processing power for the Fourier transform. Often, one is only interested in a narrow frequency range, for example between 88 and 108 MHz, which would require at least a sampling frequency of 216 MHz, not counting the low-pass anti-aliasing filter. In such cases, it can be more economic to first use a superheterodyne receiver to transform the signal to a lower range, such as 8 to 28 MHz, and then sample the signal at 56 MHz. This is how an analog-digital-hybrid spectrum analyzer works.

For use with very weak signals, a pre-amplifier can be used, although harmonic and intermodulation distortion may lead to the creation of new frequency components that were not present in the original signal. A new method, without using a high local oscillator (LO) (that usually produces a high-frequency signal close to the signal) is used on the latest analyzer generation like Aaronia's Spectran series. The advantage of this new method is a very low noise floor near the physical thermal noise limit of -174 dBm/Hz.

Additionally, we use some free spectrum analyzer software to monitor an antenna farm built with discarded antennae. We bottom load the antenna's to lower their wavelength and monitor and RFI in the audio spectrum through the Laptops on board sound card. By using all of these devices we get a clear picture of what RF is present, and can determine how much of an effect that RF may have on the environment.

As always, we encourage others to duplicate our work and share your data.