



## Wyatt Technical Services - EMC Consulting & Seminars

56 Aspen Dr.  
Woodland Park, CO 80863  
(719) 310-5418  
(877) 443-9275 toll-free  
[ken@emc-seminars.com](mailto:ken@emc-seminars.com)  
[www.emc-seminars.com](http://www.emc-seminars.com)

---

## MAKING YOUR OWN EMC TROUBLESHOOTING KIT

Those of us who are either internal or independent EMC consultants can benefit greatly by assembling our own EMC troubleshooting kits. This short article will summarize what I have in my kit and because everyone's needs might be a little different, feel free to add or subtract tools and test equipment as desired. Expect to spend about \$3k to \$4k for the complete kit, depending on whether you make a lot of DIY probes or buy commercial, but this includes a spectrum analyzer.

**Troubleshooting Kit Contents** - I've split the list of items into two groups - Phase 1 and Phase 2. Phase 1 is really the minimum I'd recommend for serious EMC troubleshooting and should cost as little as \$500 with the RF Explorer spectrum analyzer and DIY probes. Phase 2 is a list of recommended upgrades and add-ons that will prove useful if the budget accommodates. You'll eventually want one of the better spectrum analyzers, a set of commercial near-field probes



and a commercial current probe. A more fully-equipped kit should run you about \$3k to \$4k with one of the better analyzers.

The gear included in Phase I will get you started and should easily fit into one of the Pelican transit cases. I used their [Model 1514](#) roller case (a Model 1510 case with padded dividers, \$200), an idea I got from my colleague, [Doug Smith](#). I also added the lid organizer, [Model 1519](#) (\$30) for holding cables, small hand tools, and miscellaneous accessories.

**Phase I (Basic Kit)** - This kit will give you a start at the lowest possible cost, depending on the analyzer chosen. Here is a listing of the contents.

- Wide-band 20 to 3,000 MHz preamplifier ([Mini Circuits ZX60-3018G-S](#) or equiv., \$50)
- Digital Multimeter (I use one of the small \$5 models) from Harbor Freight Tools
- Family Radio Service (FRS radio for radiated immunity testing, \$30/pair)
- [AM/FM radio](#) for detecting ESD and harmonics
- UHF "bowtie" TV antenna (\$10) or 400-1000 MHz log-periodic from [www.wa5vyb.com](#)
- VHF "rabbit ears" TV antenna (\$10)
- Piezoelectric BBQ starter (for simulating ESD events, \$6)
- ZipLok® bag with a few coins (for generating ESD)
- Small driver kit (with an assortment of bits)
- Various hand tools
- Power screwdriver, such as the Ryobi Model HP53L (\$30)
- SMA connector wrench
- Pencil soldering iron ([Weller WMI20](#), \$40)
- Solder and solder-wick
- [Dental inspection mirror](#) (small mirror with long thin handle for probing in confined spots)
- Small flashlight
- Small magnifier
- [ESD wrist strap](#)

- Tape measure (English/metric)
- Tweezers
- Wire (miscellaneous sizes and lengths)
- DIY H-field and E-field probes (see my past articles)
- DIY current probe (see my past articles)
- 10 and 20dB attenuators (Mini-Circuits VAT-10W2, VAT-20W2 and HAT-10+, HAT-20+, \$12 and \$9, respectively, in SMA and/or BNC sizes)
- Various coaxial adapters
- Aluminum foil (1-2 foot square pieces folded)
- [Copper tape](#) (or “[snail tape](#)”, available from hardware/gardening stores at 1/10th the cost of EMI-rated copper tape)
- [Insulating Kapton® tape](#)
- EMI gaskets (ask manufacturers for a sample kit)
- Ferrite chokes (chip and leaded beads, clamp-on chokes, ask for a sample kit)
- Capacitors (various values, chip and leaded, in range of values: 100 pF, 1/10/100 nF, 1/10 uF)
- Resistors (various values, chip and leaded in range of values: 1/10/27/47/100/470/1k/10k/100k Ohms)
- Inductors (various values, chip and leaded in range of values: 1/10/100/1000 uH)
- Common-mode chokes (chip and leaded, ask for sample kit)
- External line filter with short line plug (used in-between line cord and product)
- Small (5x5” bare) copper clad PC board (used for shield – place in Ziplok® bag for insulation)
- Clip leads (1m long)
- Various 1m long I/O cables (USB, RS-232, Video VGA, etc.)
- Various BNC and SMA coaxial cables

**Phase 2 (Add-Ons & Upgrades)** - As you're able, you'll probably want to upgrade some of the major pieces of equipment and probes. Here's what I recommend (or try to find something equivalent).

- [Thurlby Thander \(TTi\) PSA2702T](#) spectrum analyzer (\$1.6k from [Newark Electronics](#) or [Saelig Electronics](#))
- [Rigol PSA815TG \(with tracking generator and EMI option\) spectrum analyzer](#) (\$1.8k from Rigol distributor or [www.amazon.com](#))
- Beehive [near-field probe set](#) at \$295. You'll also want to order their cable and adapter kit (SMA or BNC), as the probes use an SMB connector.
- Beehive [wideband \(150 kHz to 6 GHz\) preamp Model 150A](#), or equiv. (\$525)
- Current probe ([Fischer Custom Communications Model F-33-1](#), or equiv. (10 kHz to 250 MHz, \$1.2k)
- DIY ESD detector (see schematic in [article here...](#))
- Credence Technologies (now marketed by 3M) [ESD Aware \(Model CTC34\)](#), or equiv. (\$1k)
- ESD simulator, such as [KeyTek MiniZap](#) (\$15k)
- Digitizing oscilloscope (minimum of 500 MHz bandwidth and 4GSa/s, \$5 to 15k). I use an [Agilent DSO6054A](#).
- Qty 2 - oscilloscope probes (1:1, 500 MHz, min, 1k each)



- [Smart Tweezers RLC meter, Model ST5](#), for identifying unmarked surface-mount (and leaded) components (\$387).

**Choosing a Spectrum Analyzer** - The one piece of gear that's essential for EMC troubleshooting is a spectrum analyzer. You can buy a decent portable for about \$10k or used ones go for \$1k to \$5k if you don't mind the 30 to 80 pounds of weight or the initial investment.

GOOD - What's interesting is that I've run into a very low cost spectrum analyzer solution called the RF Explorer. It's designed by engineer, [Ariel Rocholl](#), from Spain and manufactured by [www.seeedstudio.com](http://www.seeedstudio.com), a Chinese electronics supplier for the hobbyist crowd. The RF Explorer ([Model WSUB1G](#)) is limited to a frequency range of 240 to 960 MHz, which covers quite a bit of the most desired radiated emissions band. However, it sells for just \$129, which will at least give you some idea of the emissions profile of a product under test. I've used this with the Beehive probes and it works well for general troubleshooting. They also sell the WSUB1G with added Wi-Fi receiver module, called the [RF Explorer - ISM Combo](#), for \$175. Rocholl has also completed a brand new design for a low-cost [RF Explorer 3G Combo](#) that is available now for \$269 and will tune from 15 MHz to 2.7 GHz. I reviewed the [original RF Explorer - WSUB1G here...](#) As you can see in the picture, the user interface is quite limited, so you may find it a little slower to use than the full-sized analyzers. But if price is an issue, this will work well enough.



Here's the "RF Explorer - WSUB3G", a handheld spectrum analyzer that sells for \$269 and covers 15 MHz to 2.7 GHz.

BETTER - You'll eventually want to upgrade (or start with) a better quality analyzer. I've been using the Thurlby Thander (TTi) [PSA2701T](#) (1 to 2700 MHz handheld, at \$2k) for several years

now. However, Thurlby Thander recently introduced an upgraded model [PSA2702T](#), for just \$1.6k (Newark or Saelig Electronics are the North American distributors). Many other independent consultants are also using this one. It's truly handheld and will fit into the recommended transit case.

BEST - Rigol, a test & measurement company based in China, announced the \$1,295 [Model DSA815TG](#) (9 kHz to 1.5 GHz with tracking generator) portable analyzer. The EMI option (\$599) will give you the three EMI resolution bandwidths (200 Hz, 120 kHz and 1 MHz) and quasi-peak detector. I've published a full review in the [EDN Network](#).

Either analyzer should do well for you, but my preference (if traveling light) remains the TTI because it's fast to use and fits so well into the transit case, avoiding my carrying a second piece of gear. The advantage of the Rigol analyzer is that it is more accurate and includes a preamp, tracking generator, the EMI bandwidths and quasi-peak detector. However, for that price, it's limited to just 1.5 GHz. The tracking generator is also a valuable troubleshooting tool for determining resonances and filter responses. Of course, Rigol has models that go higher in frequency (3 GHz) for a higher cost (\$6k and up with options). I've also noted recently there are several low-cost analog spectrum analyzers available, but I've also heard reports of poor reliability for many of these. Also, they will lack the means for saving instrument setups, screen captures and the like.

For more details, please visit my six-part series on assembling your own EMC troubleshooting kit at EDN Network's [EMC Blog](#). This will also show you how I use all these tools.



*The Thurlby Thander PSA2702T and Rigol DSA815TG spectrum analyzers. These fully-featured instruments each have their advantages. The PSA2701T fits easily into the roller case, while the DSA815TG (with EMI option) is ideal for pre-compliance testing (to 1.5 GHz).*