

## EMI Troubleshooting & Precompliance Equipment List

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I find the following equipment useful for troubleshooting EMI issues and performing pre-compliance testing. Note that this is not an exhaustive list, as there are many other quality suppliers of EMC test equipment. Please click the links of any recommended manufacturers on this page: <http://www.emc-seminars.com/Manufacturers/Manufacturers.html> to explore other options.



*Figure 1 – My EMI troubleshooting kit is packed in a Pelican 1514 roller case, with optional pockets mounted in the lid. Many of these items are described in my many writings.*

## Radiated & Conducted Emissions

- Calibrated EMI antenna (30 to 1000 MHz, min.) Several manufacturers make calibrated EMI antennas; A.H. Systems, Aaronia, Com-Power, ETS-Lindgren, Rohde & Schwarz, etc.
- Affordable, compact, troubleshooting antennas (limited calibration) based on PC board designs are available from Kent Electronics (<http://www.wa5vjw.com>).
- Non-metallic tripod that can hold the antenna at 1m, or more, in height (see antenna manufacturers).

- Basic spectrum analyzer (Rigol DSA800-series or Siglent SSA 3000X-series that covers up to at least 1 GHz). I also really love the portable handheld Thurlby Thandar (AIM-TTi) PSA6005USC spectrum analyzer. Saelig Electronics (see link below) sells these.
- For more advanced signal analysis, including capture and measurement of wireless signals up to 6.2 GHz, consider the real-time Tektronix RSA306B or Signal Hound BB60C USB-powered modular real-time analyzer, or other lab-grade bench top analyzers from Keysight Technologies, Rohde & Schwarz, etc.
- Non-metallic table for EUT (could be manual turntable or even a roll-around cart).
- Ideally a ground plane, but most pre-compliance setups just use the floor.
- Line Impedance Stabilization Network (LISN) for conducted emissions. These come in DC or AC models. Consider the models from Com-Power, ETS-Lindgren, Rohde & Schwarz, or TekBox Technologies.

#### **IEC/EN 61000-4-2 (ESD)**

- ESD simulator. One of the best-performing units is the Thermo Keytek "MiniZap", however, they are out of production, but used units may still be found on eBay, or other used equipment dealers. Be sure any KetTek unit has all the accessories (charger, ground lead and both CD and AD tips. If the NiCd battery is bad, check The EMC Blog for replacement instructions. New units are available from many manufacturers, such as EMC-Partner, EM Test, Haefley, Noiseken, Teseq, and others.
- ESD test table. Construct according to the IEC 61000-4-2 standard. Will require a ground plane.

#### **IEC/EN 61000-4-3 (Radiated Immunity)**

- RF generator with a minimum of +10 to +20 dBm output, at 80 to 2700 MHz, capable of 1 kHz 80% AM modulation. Use with near field probes to inject a signal. Modular USB-controlled RF generators are available from Signal Hound, TPI, and Windfreak Technologies. Bench top RF generators are available from Keysight Technologies, Rohde & Schwarz, Siglent Technologies, and Rigol Technologies. See also references 4 and 5 for details on testing.
- OR Use a TEM cell (check out the "open" cells by Tekbox Technologies. See reference 6.
- OR Use a common Family Radio Service (FRS) two-way radio for a gross check at 465 MHz.

#### **IEC/EN 61000-4-4 (Electrically Fast Transient - EFT)**

- EFT generator is best.
- OR Use a KeyTek MiniZap ESD simulator (or equivalent), inductively coupled to the power cord and set to 20 pps. See reference 4.

#### **IEC/EN 61000-4-5 (Power Line Surge)**

- Surge tester. There is no cheap workaround for this. Best to rent as needed.

#### **IEC/EN 61000-4-6 (Conducted Immunity)**

- RF generator (150 kHz to 80 MHz, 3Vrms, 80% modulation).
- Will probably need a 10W (or more) broadband power amplifier that covers these frequencies.
- Various injection clamps for the line cord and coupling networks for Ethernet (cables shorter than 3m are not tested). See Reference 8 for alternative test methods.
- Sometimes it's just better to rent one.

## IEC/EN 61000-4-11 (Power Line Dips, Brownouts)

- Power line tester. There is no cheap workaround for this. Best to rent as needed.

## Miscellaneous Equipment

- RF clamp-on current probe. Several manufacturers make these; Com-Power, Fischer Custom Communications, Pearson Electronics, Rigol and Tekbox Technologies. I have used probes from all three of these manufacturers, but use the Fischer Custom Communications F-33-1, mostly.
- Near field probe set (Check out Beehive Electronics, Rohde & Schwarz, Länger EMV, Tekbox Technologies, Siglent, or Rigol).
- Small digital multimeter.
- Of course, you'll also need some general-purpose ferrite chokes and common mode filters. I really like Würth Elektronik, who provides an easy and quick way to get samples from their web site (see link below).
- You'll also want to collect copper tape, aluminum foil, wire ties, EMI gaskets, finger stock, and some simple hand tools to outfit your kit.
- The book, *EMI Troubleshooting Cookbook for Product Designers*, authored by Patrick André and myself, explains a lot of EMI troubleshooting and pre-compliance testing that can be performed in-house. See reference 8 below.

## References

1. Check out my numerous blog postings on EDN.com (The EMC Blog, <http://www.edn.com/electronics-blogs/4376432/The-EMC-Blog>) and Interference Technology (<https://interferencetechnology.com/author/kennethwyatt/>)
2. **The HF Current Probe: Theory and Application -** <http://www.interferencetechnology.com/the-hf-current-probe-theory-and-application/>
3. **Assembling A Low Cost EMI Troubleshooting Kit – Part 1 (Radiated Emissions)** <http://www.interferencetechnology.com/assembling-low-cost-emi-troubleshooting-kit-part-1-radiated-emissions/>
4. **Assembling A Low Cost EMI Troubleshooting Kit – Part 2 (Immunity).** Refer to the article in Interference technology's 2016 Test & Design Guide (<http://learn.interferencetechnology.com/2016-emc-test-and-design-guide/>)
5. **Inexpensive Radiated Immunity Pre-Compliance Testing** <http://www.interferencetechnology.com/inexpensive-radiated-immunity-pre-compliance-testing/>
6. **Using a TEM Cell for Radiated Emissions and Immunity Troubleshooting.** Refer to the article in Interference Technology's 2016 Test & Design Guide (<http://learn.interferencetechnology.com/2016-emc-test-and-design-guide/>)
7. Estonian Center for Standardization sells low-cost EMC standards: <https://www.evs.ee/shop>
8. *EMI Troubleshooting Cookbook For Product Designers* [https://www.amazon.com/Kenneth-Wyatt/e/B00SNQ1LJ2/ref=dp\\_byline\\_cont\\_book\\_2](https://www.amazon.com/Kenneth-Wyatt/e/B00SNQ1LJ2/ref=dp_byline_cont_book_2)
9. [Saelig Electronics](http://www.saelig.com/category/EMC.htm) sells products from Rigol, Siglent, and TekBox. <http://www.saelig.com/category/EMC.htm>

10. Other manufacturers mentioned:

- a. Aaronia AG - <http://www.aaronia.com>
- b. EM Test - <http://www.emtest.com/home.php>
- c. EMC Partner - <https://www.emc-partner.com>
- d. Haefley-Hipotronics - <http://www.haefely-hipotronics.com>
- e. Kent Electronics - <http://www.wa5vjb.com>
- f. Keysight Technologies - <http://www.keysight.com/>
- g. Noiseken - <http://www.noiseken.com>
- h. Rohde & Schwarz - [https://www.rohde-schwarz.com/us/home\\_48230.html](https://www.rohde-schwarz.com/us/home_48230.html)
- i. Rigol Technologies - <https://www.rigolna.com>
- j. Siglent Technologies - <http://siglentamerica.com>
- k. Signal Hound - <https://signalhound.com>
- l. TekBox Technologies - <https://www.tekbox.net>
- m. Tektronix - <http://www.tek.com>
- n. Teseq - <http://www.teseq.com/en/index.php>
- o. Thurlby Thandar - <https://www.aimtti.com/product-category/spectrum-analyzers>
- p. Thermo Keytek - <https://www.thermofisher.com/us/en/home.html>
- q. TPI - <http://www.rf-consultant.com>
- r. Windfreak Technologies - <https://windfreaktech.com>