

ESD—Electrostatic Discharge— Part 2

Is *your* workbench ESD safe? With a few inexpensive tools and proper precautions, it can be.

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Last month, I discussed the generation of ESD, its hazards and some ways of avoiding damage to your electronic equipment and components. This article wraps things up by telling you a bit more about ESD and what you can do to make your workbench ESD-safe.

Some ESD Considerations

Chances are, most of us will eventually work on a piece of solid-state gear. Without the appropriate antistatic equipment, (see "Supply Sources" in the Appendix) you'll subject that gear to unnecessary ESD risk. Many ESD products (such as static-dissipative gloves, hats, garments, shoes, and floor and wall finishes) are impractical for most amateurs to consider. Other products, however, such as antistatic tools, desktop air ionizers, wrist/ankle straps and conductive mats are both readily available and affordable. Even the more-expensive and specialized ESD equipment can sometimes be found at swap fests, so it's important for you to become aware of what's out there and what it can do.

Tools

A number of antistatic tools are available for working with static-sensitive components. Antistatic IC insertion and extraction kits, including antistatic DIP pliers and tweezers, are useful additions to any amateur's toolbox. Antistatic soldering systems, both stand-alone soldering irons and temperature-controlled stations, are available from Weller and Ungar. The major difference between the antistatic models and the conventional irons available from these manufacturers is the composition of the plastic used to construct the handles and stands of the soldering irons. Instead of a nonconductive blue plastic, the antistatic irons use a black, carbon-impregnated plastic that can bleed static charges to ground. Prices for antistatic soldering irons from both Weller and Ungar start at about \$70, with temperature-controlled models ranging from \$75 to almost \$300.

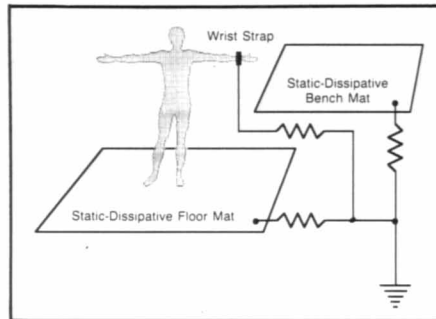


Fig 4—Inexpensive, easily obtained protection against ESD-induced damage includes static-dissipative bench and floor mats, as well as wrist straps. To bleed off static charges from personnel and devices on the mats, wrist straps and mats must be connected to ground through a 1- to 10-M Ω -resistor.

Ionizers sold for home air purification should not be used for ESD prevention.

Mats

Static-dissipative plastic mats, available for both floors and desktops, are useful for transforming any flat surface into an ESD-safe environment (see Fig 4). These mats, composed of carbon-impregnated plastic, are especially handy when you don't have access to a permanent work area that can be ESD-proofed (when your workbench is a kitchen or dining-room table, for example). For proper operation, static-dissipative mats must be connected to ground through a several-megohm resistor from a single point on the mat. Mats are relatively inexpensive, with prices starting at about \$30.

Wrist Straps

Conductive wrist and ankle straps (see Figs 5 and 6), when connected through a 10-megohm resistor to ground, provide a low-resistance path for dissipating the static charge, but not so low as to present an electric shock hazard. Commercial units can be had for about \$10. For instructions on how to build a low-cost wrist-strap system, see the article by George Peacock, W4WYV.⁶

⁶Notes appear on p 29.



Fig 5—Conductive wrist straps are an inexpensive and effective means of dissipating static charges from the body. In this assembly, a 1-M Ω resistor has been molded into the plastic cap on the ground-cord snap fastener. When the alligator clip is connected to ground, static charges on the body are bled to ground through the resistor.



Fig 6—A conductive wrist strap in use. The strap should fit snugly to ensure good electrical contact.

Aerosol Coatings

Antistatic sprays (such as Staticide or Static Free) are useful in neutralizing and eliminating static buildup. These sprays—about \$8 to \$12 for 32-oz pump bottles of liquid or \$6 for 16-oz aerosol cans—leave a clear film that neutralizes existing static charges and minimizes subsequent static accumulation.

Air Ionizers

Air ionizers, although somewhat extravagant for an amateur's workbench, are extremely effective in neutralizing static charges on nonconducting objects in their immediate vicinity, such as tools and components within three or four feet of the ionizer unit.

Normally, room air is composed predominantly of electrically neutral atoms (neutral atoms have an equal number of negatively charged electrons and positively charged protons) of nitrogen, oxygen, helium, etc. Because it's relatively rare for any atoms comprising room air to lose electrons (thereby becoming positive ions or *cations*) or gain them (becoming negative ions or *anions*), typical indoor ion density is only a few hundred ions/cc. In comparison, ion densities in the 50,000 to 500,000 ions/cc range can be realized with ionizers designed for ESD protection. Ionized atoms conduct electricity with greater ease than do electrically neutral atoms.

Though the ionization of gases in the air can be accomplished through the use of heat or other types of radiation, commercial antistatic ionizers rely on electron-atom collisions.⁷ Electrons, accelerated by a high-voltage discharge (5- to 10-kV), collide with atoms in the air, knocking electrons off some atoms (forming cations), and donating electrons to others (forming anions). Although RF noise may be associated with these high-voltage discharges, it should not pose a problem to most amateurs, because ionizers should be used

Air-Ion Balance and Health

Unlike antistatic ionizers, which are designed to produce an equal number of cations and anions, residential air ionizers, often marketed as air-purification systems, are designed to produce anions. These anions in turn become attached to dust particles in the air, which also become negatively charged. Walls, floors, furniture, and other surfaces with a net positive or neutral charge attract these charged dust particles, precipitating them from the air.

In addition to removing dust particles from the air, room air ionizers also have a significant effect upon the ion balance in a room. Environmental pollution, ducted air conditioning, air heaters, and many types of electronic equipment decrease the air-ion density. Although air in the countryside tends to have a net negative ion balance, polluted city air is likely to have a very low to nonexistent ion density, suggesting that a negative ion balance is somehow beneficial. Although controlled medical studies have not shown conclusively that this is true, the research to date suggests that a high cation density is associated with headaches, irritability, and reduced psychological performance (see note 7). In short, the lack of negative ions is thought to lead to human stress.

Because ionizers designed for ESD applications cause the formation of equal quantities of cations and anions in the air, there is no evidence that their use can result in physiological stress. However, because the significance of ion balance and concentration on human health is not yet fully understood, exercise caution when using an antistatic ionizer. That is, use it when you work with static-sensitive devices, and turn it off as soon as you are finished.—*NU1N*

only when ESD-sensitive devices are actually being handled (you'll be at the workbench and not on the air).

Properly designed antistatic ionizers produce an equal number of cations and anions. This balance is important in ensuring that there are enough positive and negative ions in the air for effective static neutralization of objects with a net positive or negative charge. If a tool has a net negative charge, cations from an ionizer will attach to the tool surface, neutralizing the charge. Similarly, an object with a net positive charge will be neutralized by anions.

Residential room air ionizers, sometimes sold as air-purification devices (see the sidebar, "Air-Ion Balance and Health"), should not be confused with commercial ionizers designed for ESD protection. Residential ionizers are designed to spew free electrons into the air, increasing the concentration of anions and neutralizing any cations in the air. Therefore, if an object has a net negative charge, a residential air ionizer will not help neutralize the charge. *Ionizers sold for home air purification should not be used for ESD prevention.*

Smoking depletes the air of ions, diminishing the efficacy of any ionizing system.

Smoking depletes the air of ions, diminishing the efficacy of any ionizing system. If you're going to rely on an ionizer to protect sensitive components, *don't* smoke. Even if you don't care about your health, the tar and other airborne products of smoking can compromise the function-

ality of your communications equipment, computers, and peripherals.

Although good for neutralizing electronic components and tools, ionizers will not neutralize charges that have accumulated on your clothing and body. Ionizers should therefore be used in conjunction with a good wrist- or ankle-strap system. Desktop antistatic ionizers prices start at about \$200, with room ionizers costing considerably more.

Summary

Radio amateurs working with solid-state components, servicing microprocessor-controlled communications equipment or working with microcomputer hardware, should be aware of the threat of ESD-induced damage and know how to avoid it. By observing a few inexpensive and easily implemented precautions during component storage and handling, potential ESD damage can be minimized, if not eliminated entirely. Is *your* workbench ESD safe?

Notes

⁶G. Peacock, "The Spark Zapper, A Static Electricity Discharge Device," *CQ*, Mar 1989, pp 36-38.

⁷*The New Illustrated Science and Invention Encyclopedia* (Westport, CT: H. S. Stuttman, Inc, 1987).

APPENDIX

Supply Sources

Because ESD protection is a hot topic in the commercial electronics industry, there is a wide variety of anti-ESD products on the market. The November 1989 issue of *Evaluation Engineering* contains a cross reference of ESD products and services offered by over 400 companies. Although I suggest that you make use

(continued on page 33)

antennas to be mounted higher without concern for feed-line loss, less transmitter power is required for the same coverage and less dc power is needed, because there's no power-hungry relay to energize.

On the higher bands (5760 MHz and up), where dish antennas are used almost exclusively, most operation is done at mountaintop locations. You can make dish feeds using dual-polarization feed systems with two orthogonal probes. This makes a single dish into two antennas (and guarantees that both antennas are on the same beam heading!). The fixed station could transmit with, say, horizontal and receive with vertical polarization; the rover station(s) would receive horizontal and transmit vertical polarization.

Walt Bohlman, K3BPP, gave me another idea for a separate-antenna system using a dish. Walt suggested making a feed using two pieces of waveguide tapered to a single piece that extends to the dish focus, as shown in Fig 3. Although I haven't tried this, it seems to be a way to get same-polarization receive and transmit from one reflector without TR switching. The focus end of the feed, as well as the transmit and receive ends, would be terminated in waveguide-to-coax transitions. Tuning screws mounted at the Y point would serve to tune the assembly for minimum loss and best isolation between the transmit and receive ports. The single end would then be cut off, and the slotted feed/splash plate⁹ fabricated. I'm interested in hearing from anyone who tries this.

Again, the antennas can be mounted as high as possible without regard to feed-line losses. For temporary installations (such as mountaintop stations), the complete transverter system can be mounted on the rear of the dish using short pieces of cable to the feed. A piece of RG-58 cable from the IF radio to the antenna-mounted units would work well, no matter how high the antenna is mounted.

Summary

At microwave frequencies, where high transmitter power is relatively hard to come by (and expensive), it's to our advantage to use separate antennas to cut costs, improve station performance and help increase the populations of the UHF and microwave bands.

For amateurs who are fortunate enough to have high-power TWTAs (traveling-wave-tube amplifiers), the conventional low-loss transmission line (or waveguide) is still needed. There's no reason, however, why a separate-antenna system couldn't also be used. The advantages of having the receive preamplifier at the antenna and no need for an antenna relay still makes this high-performance system practical and useful.

It is now possible for the average ham, running only milliwatts, to make contacts on the higher UHF and microwave bands.

I find this kind of operation more challenging and more fun than VHF/UHF communications, as do many of the growing numbers of hams getting on these bands. Give it a try!

Notes

¹Rick Campbell, KK7B, and Jim Davey, WA8NLC, have collaboratively designed single-board, no-tune transverters for the 903- through 5760-MHz amateur bands. See the following articles on these transverters:

- R. Campbell, "A Single-Board No-Tuning 23 cm Transverter," *Proceedings of the 23rd Conference of the Central States VHF Society* (Newington: ARRL, 1989), pp 44-52.
- J. Davey, "No-Tune Transverter for 2304 MHz," *Proceedings of Microwave Update '89* (Newington: ARRL, 1989), pp 30-34.
- J. Davey, "A No-Tune Transverter for 3456 MHz," *QST*, Jun 1989, pp 21-26. Also see Feedback, Oct 1990 *QST*, p 31.
- R. Campbell, "A Single-Board Bilateral 5760-MHz Transverter," *QST*, Oct 1990, pp

27-31. This article lists, in its end notes, sources for lots of information on microwave antennas and other subjects of general interest.

The *Proceedings* books are available from ARRL for \$12 each plus \$2.50 shipping and handling. A *QST* article by Rick Campbell on the 903-MHz version is forthcoming.

²Loop-Yagi antennas and KK7B/WA8NLC 10- to 20-mW, single-board, no-tune transverters are available from Bill Olson, W3HQT, Down East Microwave, RR 1, Box 2310, Troy, ME 04987, tel 207-948-3741. Catalog available.

³In this context, the feed line includes the jumper connected to the antenna, the cable around the rotator (the "flex loop"), the main transmission-line run, the antenna relay and the jumpers connecting the receiver and transmitter to the relay.

⁴B. Olson, ">50," *QEX*, Aug 1987, pp 15-16.

⁵L. Wolfgang and C. Hutchinson, eds, *The ARRL Handbook* (Newington: ARRL, 1990), pp 16-14 and 16-15.

⁶See note 2.

⁷B. Atkins, "The New Frontier," *QST*, Aug 1987, p 59.

⁸See notes 1 and 2.

⁹B. Atkins, "The New Frontier," *QST*, Dec 1987, p 64. 

ESD—Part 2

(continued from page 29)

of this reference, most of the basic ESD supplies can be obtained from the suppliers listed below:

Wrist Straps & Work Mats

Hub Material Co, 33 Springdale Ave, Canton, MA 02021, tel 800-482-4440 (617-821-1870 in MA).

Jensen Tools Inc, 7815 S 46 St, Phoenix, AZ 85044, tel 602-968-6231.

MCM Electronics, 650 Congress Park Dr, Centerville, OH 45459, tel 513-434-0031.

Specialized Products Co, 2117 W Walnut Hill Ln, Irving, TX 75038, tel 800-527-5018.

Conductive Foam

Hub Material Co, 33 Springdale Ave, Canton, MA 02021, tel 800-482-4440 (617-821-1870 in MA).

MCM Electronics, 650 Congress Park Dr, Centerville, OH 45459, tel 513-434-0031.

Specialized Products Co, 2117 W Walnut Hill Ln, Irving, TX 75038, tel 800-527-5018.

Antistatic Coatings

ACL Inc, 1960 E Devon Ave, Elk Grove Village, IL 60007, tel 312-981-9212.

Charleswater Products, Inc, 93 Border St, West Newton, MA 02165, tel 617-964-8370.

Hub Material Co, 33 Springdale Ave, Canton, MA 02021, tel 800-482-4440 (617-821-1870 in MA).

Tech Spray, PO Box 949, Amarillo, TX 79105, tel 800-858-4043.

Antistatic Packaging

Hub Material Co, 33 Springdale Ave, Canton, MA 02021, tel 800-482-4440 (617-821-1870 in MA).

Maine Poly Inc, PO Box 8, Greene, ME 04236, tel 207-946-7440.

Plastic Systems, Inc, 261 Cedar Hill St, Marlboro, MA 01752, tel 508-485-7390.

Republic Packaging Corp, 9160 S Green St, Chicago, IL 60620, tel 312-233-6530.

Specialized Products Co, 2117 W Walnut Hill Ln, Irving, TX 75038, tel 800-527-5018.

Static Inc, Old Sherman Tpk, Danbury, CT 06810, tel 203-791-3600.

Ionizers

Corion Technologies, Inc, 215 Salem St, Woburn, MA 01801, tel 617-933-8558.

Hub Material Co, 33 Springdale Ave, Canton, MA 02021, tel 800-482-4440 (617-821-1870 in MA).

Ion Systems, Inc, 2546 Tenth St, Berkeley, CA 94710, tel 415-548-3640.

Simco Company, Inc, 2257 North Penn Rd, Hatfield, PA 19440, tel 215-822-2171.

Semtronics, PO Box 94, Oldwick, NJ 08858, tel 201-534-5196.

Antistatic Tools

Jensen Tools Inc, 7815 S 46 St, Phoenix, AZ 85044, tel 602-968-6231.

Antistatic Apparel

Oak Technical, Inc, 219 S Sycamore St, Ravenna, OH 44266, tel 216-296-3416.

Prudential Overall Supply, 6948 Bandini Blvd, Los Angeles, CA 90040, tel 213-722-0636.

Worklon, 10099 Seminole Blvd, Seminole, FL 34642, tel 800-727-8643. 