Keith Greiner AKØQ
421 N. Pleasant Hill Blvd.
Des Moines IA 50317

Surviving the Unthinkable

—part I: the ham's role

Today they hauled out the last of the Civil-Defense supply cans from our office building. It wasn't much of a loss, however, because long ago the familiar drab green cans with their black lettering had been emptied of their contents. Once they had stored food, water, medical supplies, radiation-monitoring equipment, clothes, etc., enough material for several hundred people to survive for two weeks after a worldwide nuclear holocaust.

The fallout shelter sign is a symbol of protection which is now giving way to crisis relocation plans.

But the food grew rancid and the other materials deteriorated. With several reorganizations of the building, the cans constantly were reshuffled into corners until, finally, there was no other place to put them but out with the trash. Tonight they most likely grace the garage of a member of the maintenance staff who saw them as too good to discard and recovered them to use for workshop trash, discarded cuttings from his table saw, or some such refuse.

The case here is common. The once-familiar sight of fallout shelter supplies gracing the basements of public buildings has all but disappeared. Only a few of the once-common fallout shelter signs remain. Most likely, if you care to check a building displaying a shelter sign, you will find plenty of shelter and no usable supplies.

So, what would happen if our nation's 225 million people suffered an attack by a nation using nuclear warheads? Are we totally unprotected? Out of luck? Frankly, according to civil-defense planners, people heading for those old-style shelters might be out of luck, anyway. The shelters are often located in downtown areas of large metropolitan areas. With a direct hit to one of these cities, it is very likely that the shelter would provide as much protection to its occupants as no shelter at all. Cities where this problem is expected to occur are shown

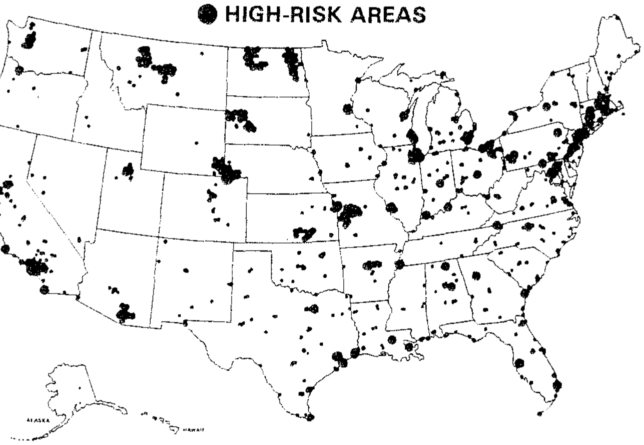


Fig. 1. The dots here represent possible high-risk areas which require crisis relocation plans.

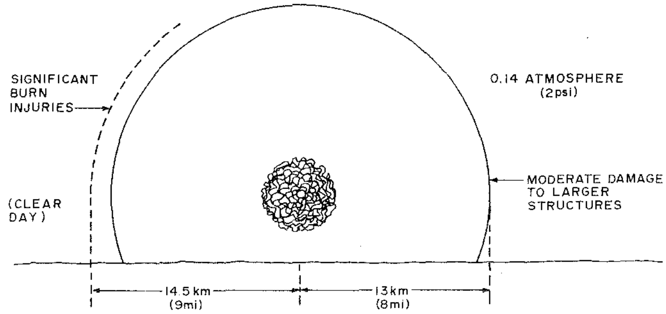


Fig. 2. Expected effects of 1-megaton air blast.

in Fig. 1, which is a map of cities most likely to receive direct hits in an all-out nuclear war.

The idea of these home cities being targets of some foreign nuclear power is not a pleasant thought. But in a world of increasing tensions, there no doubt will be an increased interest in our praying for peace, and also preparing for our own personal defense in the event our world leaders some day fail to keep the peace.

As an alternative to hiding in big-city shelters, planners suggest that it may be better to move people out of the crucial areas where devastation is most likely to occur. (Fig. 2 shows the sphere of effect for each 1-megaton device.) This plan is apparently patterned after a Russian plan discovered several years ago.

According to a recent publication of the Federal Emergency Management Agency, which now handles civil defense, the new plan is as much a negotiation plan as anything. They feel that in a game of superpower brinksmanship, where each side will see just how far the other will go before "pushing the button," the Russians would most likely evacuate their cities as a defense mechanism before launching an attack on us. Naturally, the planners feel our intelligence sources would let us know of the evacuation. At that point, we would rely on our country's availability of rapid transit and family cars to completely evacuate before the Russians do. We would then declare that since we're safe and they're not, they should back off and forget about blowing us to oblivion.

There are some good points about the plan. It is true that the United States has great versatility due to our widespread use of private cars, while the Russians cannot afford to have a car in every garage and would need to rely on trains, buses, and "marching routes" to move their people 30 to 200 miles from major cities. An illustration of their plan is shown in Fig. 3. The weather, however, complicates survival, as shown in Fig. 4.

Calculating the cold hard facts and the alternatives of attack plans, civil-defense authorities in the US figure that if the Russians attacked before evacuating, they would lose about 100 million civilians. On the other hand, if they evacuate first, they would lose a mere 20 million.

A non-classified Federal Emergency Management Agency report issued in October, 1980, states five key points about a Soviet attack strategy.

"1) The Soviets probably have sufficient blast-shelter space in hardened command posts for virtually all of the leadership elements at all levels (about 110,000 people).

2) With a few hours of warning or less, the Soviets would suffer over 100 million casualties, but a large percentage of the leadership elements probably would survive.

3) With 2 or 3 day of preparation, the Soviets would suffer less than 50 million casualties.

4) With a week (or more), they would suffer casualties in the low tens of millions.

5) Therefore, the critical decision to be made by the Soviet leaders in terms of sparing the population would be whether to evacuate cities. Only by evacuating the bulk of the urban population could they hope to achieve a marked reduction in the number of urban casualties."

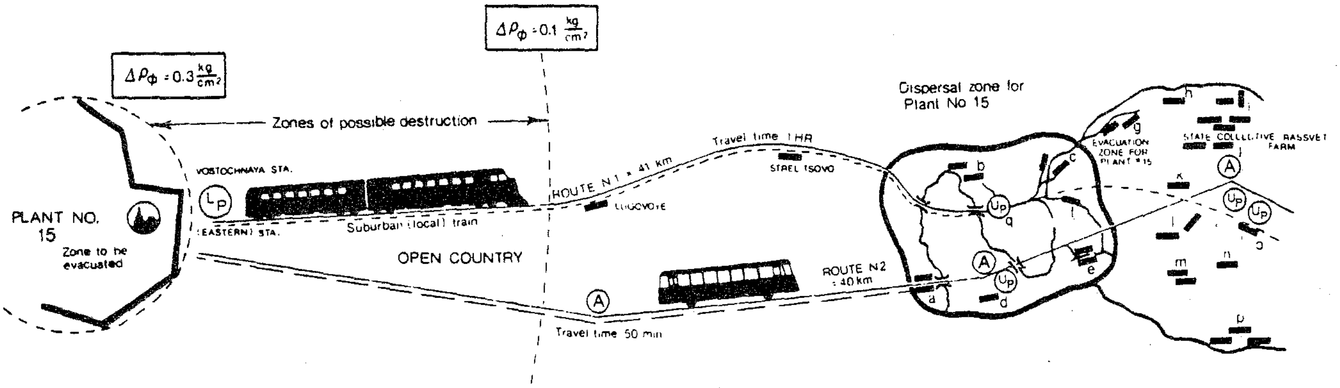
The same reasoning applies to the United States. The most horrifying part of the statistics is that at the very least we're talking about tens of millions of lost lives. And that doesn't count radiation sickness, burns, exposure, starvation, etc.

The United States system was scheduled to be in place for most all cities during 1981. Under the system, planners believe that 80% of our population would survive to rebuild. Again, they do not estimate the aftereffects of such a disaster on the survivors of any nation.

Even after the plans are completed, there will be much additional work to be done: Shelters need to be constructed; managers need to be trained; tests of the system must be made, followed by evaluation of the tests and redirection based on the results of the tests.

Amateur radio is not mentioned in the FEMA publication sent to me regarding the crisis relocation plan. The response I received from an FEMA official states, "Those amateur radio operators who operate with Radio Amateur Civil Emergency Services (RACES) are still a very important part of civil preparedness. RACES licenses as such are no longer being issued by the FCC, but each RACES operator uses his own call letters. However, these persons must be recognized as part of the civil-preparedness organization in order to operate during emergencies under the auspices of RACES. Any RACES planning should be done with your own state of Iowa and the FCC."

Such planning is of little consolation to the residents of a state when they find out that nearly all of the state's (Iowa) 4,000 hams cannot operate, and the few licensed to operate the state's RACES station left the state one day ahead of a nuclear attack.



a Krasnoye	e Lopukhovo	i Chernava	m Lukino	q Maslovka Station	Total relocated:
b Maslovka	f Dvoriki	j Pavlovo	n Markovo		311 workers & employees
c Karpovo	g Vyselki	k Sredniy	o Zhuravlevo		253 dependents
d Setun'	h Krapivino	l Goloveno	p Aleshkino		564

(Lp) Loading point (Up) Unloading point

Fig. 3. According to the Federal Emergency Management Agency, this diagram shows Soviet plans for a crisis relocation program. The plan calls for dispersal of the population and daily commuting of workers to their places of employment.

By comparison, the May, 1980, issue of *73 Magazine* carried an article which described amateur activities when about 300,000 people came to Des Moines, Iowa, for an afternoon visit with Pope John Paul II. More than 150 local and statewide amateur radio operators provided excellent health and welfare services that day. The ratio of ham operators to population was about one amateur station for every 2,000 people. A substantially greater ratio was provided in areas where the sick and invalids were.

The situation in Des Moines was perhaps the best possible test of a crisis relocation program anywhere in the world since planners considered the notion of relocating hundreds of thousands of people. It was a complex program which was not easily undertaken. But on the specific point of supply of amateur radio operators, if the same ratio of amateur radio stations to population were applied to a national crisis-relocation program, *one out of every three* amateur radio stations in this country would need to be on the air in some assigned duty all the way from two meters through 160 meters. CW, FM, and SSB, in hundreds of orderly, planned, and tested networks, would be needed.

Fig. 4. This is one of many possible distributions of fallout from a nuclear attack on the United States. The actual distribution would, of course, depend on the location and number of actual strikes and weather conditions.

It is extremely unlikely that the present RACES system could come close to meeting the needs. As of December, 1979, there were only 610 officially licensed RACES stations on the FCC's books. We would need no less than 112,000 dedicated patriotic and very brave volunteers and their equipment.

The time is definitely here for amateurs to approach their local civil-defense authorities and the FCC to have this now-sophisticated service available on a widespread basis to every interested amateur radio operator in the event of a national emergency. Amateur radio is the only service which can provide a most-reliable communications system under severe circumstances when, for example, the entire telephone system would be rendered totally useless, merely because major switching locations would no longer exist!

Ham radio operators should be encouraged to improve their Morse-code capabilities, because under such strenuous situations, when even an amateur system may reach its peak in traffic-handling capabilities, every cycle of bandwidth of spectrum space is vital to the proper completion of the task. Currently, only CW operation can offer a bandwidth of just a few hundred cycles.

Right now, none of us, in our wildest dreams, can imagine how horrifying the world would be after a nuclear war. Our surviving population would need all the possible assistance that could be mustered, including medical supplies, food, and shelter, to name only a few. The existence of the top-notch amateur system like the one we now have could be the single most important item and could provide the key to our success.

In part II of this article, I will provide some details on just what can be done at each of our ham stations to lessen the danger to our communications systems. Some methods are simple, others incredibly expensive, but all of us can do something. ■

Acknowledgement

Figs. 1 through 3 are from *US Crisis Relocation Planning*, Federal Emergency Management Agency, 1980.

Keith Greiner AK0Q
421 N. Pleasant Hill Blvd.
Des Moines IA 50317

Surviving the Unthinkable

—part II: some practical ideas

In part I, I talked about the *idea* of emergency communications after a nuclear attack and the benefits the Amateur Service might provide. In this part, we'll talk about specific steps that each of us can take. First, though, let's set the stage:

Imagine this situation for a moment: The most incompetent of operators walked into your shack and for a fraction of an instant connected your receiver's antenna terminals to a high-voltage distribution line. The result was a 40-kV, 1,000-Amp shock to the input of your receiver. There wouldn't be very much left of your sensitive input circuits, to say the least.

This sounds like an impossible situation. I only wish that it were truly impossible. But in today's crisis-oriented world, the situation is indeed within the realm of possibility. The 40-kV shock is what civil-defense experts say would be the result of a nuclear blast in the vicinity of most any piece of unshielded wire, including telephone wires, power lines, antennas, and feedlines. The phenomenon is commonly referred to as a nuclear electromagnetic impulse (EMP or NEMP).

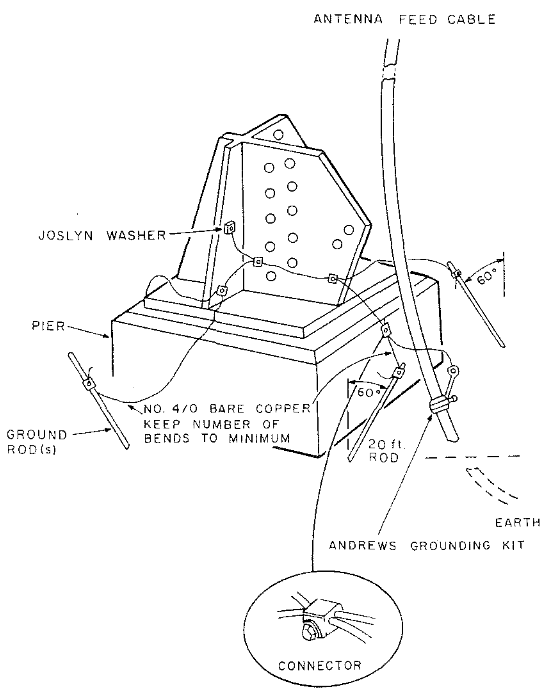


Fig. 1. Recommended ground connections at tower base.

This kind of pulse is so extreme in amplitude that many normal lightning protectors are useless. For example, a typical lightning pulse has about a 100-microsecond duration, with a 5-microsecond rise to its peak. A high-altitude EMP pulse can be expected to have a 1-microsecond duration and a 10-nanosecond rise to its peak. That's not enough time for many common lightning arrestors to work.

In the following pages we'll talk about some of the EMP protective measures which should be taken on your equipment. Without protection, sensitive semiconductors would be most likely to fail and put you out of business when your services may be needed most.

But, first, why should we even be concerned about protection? After all, any nuclear exchange seems to be so outrageously incompetent on the part of world leaders that it seems that it never could happen. Unfortunately, however, we've seen in the last few years that many improbable things such as revolutions, hostage taking, etc., have actually occurred.

Even though we all hope and pray that a nuclear exchange does not occur, let us not underestimate the devastating and paralyzing effects of such an exchange. Simply imagine, for a moment, a world with *hundreds of millions* of US and Russian citizens killed and *tens of millions* more severely and untreatably burned, near death, and starving. Major cities, with their sophisticated hospitals, police, telephone communication systems, radio and television stations, transportation, food distribution networks, financial centers, and manufacturing centers all eliminated—gone—not much usable left, and most likely too radioactive to approach for many years to come. The situation might be reminiscent of the Cambodian experience of recent years, where a ruthless and irresponsible leadership evacuated the cities and forced an entire country into an unnecessary disaster. Imagine that situation in your community, among your friends—perhaps worldwide!

However, even in the worst of disasters, there will be some survivors. If not us, then our friends or relatives. Perhaps our children or grandchildren will be among those fortunate survivors. There also will be some amateur radio operators. Perhaps the best thing that we can do for these people faced with a completely unknown and hostile environment is to ensure that they have every possible assistance available to help them through the crisis.

In communications, that assistance means that in a world where the established public system is no longer available, the technical preparations of amateur radio operators may make the difference between life and death for countless hundreds of thousands. It could be the final foothold in their struggle for survival. After all, assistance during disasters is one of our key elements, and a justification for an Amateur Radio Service. Only amateur radio operators can supply an organized communication system from almost every community in this country. Only amateur radio operators can supply this system with a substantial portion of the surviving equipment easily made operational after the shock of a nuclear explosion. Citizens Band equipment for the most part would be rendered totally useless by its unprotected reliance on semiconductors and its tendency for total disorganization even in times when there is no crisis.

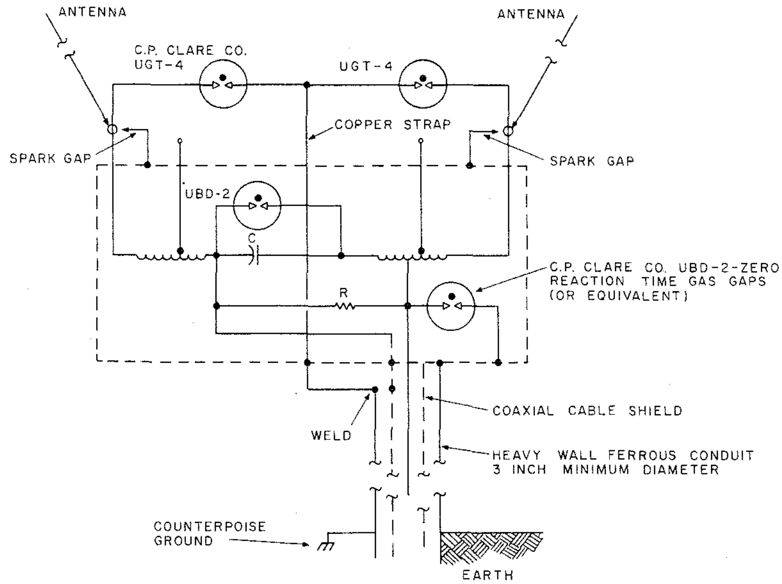


Fig. 2. Suggested use of gas gaps in an antenna balun. Note that this approach uses a thick-wall conduit around the coax.

The job of amateur radio equipment protection is easy once we realize that it does not need to be difficult or complex. Most any technical or non-technical operator can accomplish *some* EMP protection on short notice, with a very small outlay of money. The objective is to safely bypass your equipment and any incoming connections when they are presented with an EMP signal composed of 40 to 50 kV and current in the order of 1,000 Amperes.

It is interesting to note that much of the EMP protective equipment available today has been designed since our country stopped testing nuclear weapons. As a result, none of it has received the only true test of reliability—on-the-job testing—although EMP simulators are used.

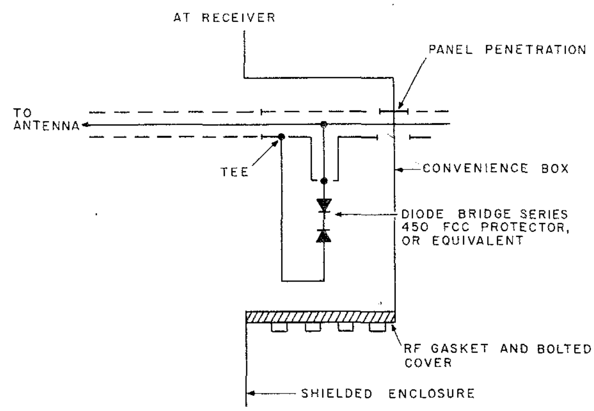


Fig. 3. Coaxial tee protectors used in a receiver circuit.

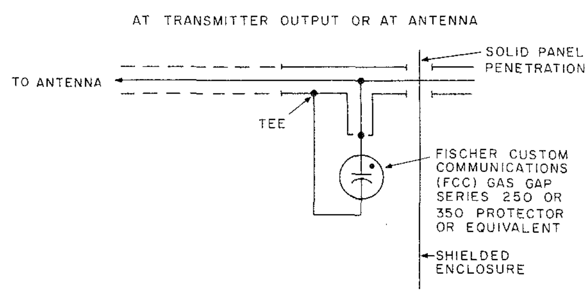


Fig. 4. Coaxial tee protectors shown in a transmitter circuit.

Because of the lack of widespread testing capabilities, the only really proven method of protection is also the simplest. Under this approach, all equipment to be protected should be disconnected from all external wires and stored in a thoroughly sealed and shielded box. The box should have no holes where any kind of energy can get in and should have a skin made of 18- to 26-gauge metal to provide magnetic shielding for the equipment inside.

Since the civil-defense planners expect to have Americans moved to a safe location 30 to 200 miles from their community, depending on the nature of threat to that community, the equipment should likewise be moved to a location 30 to 200 miles from the community.

Keep in mind when storing your equipment that power supplies also should be shielded and stored with

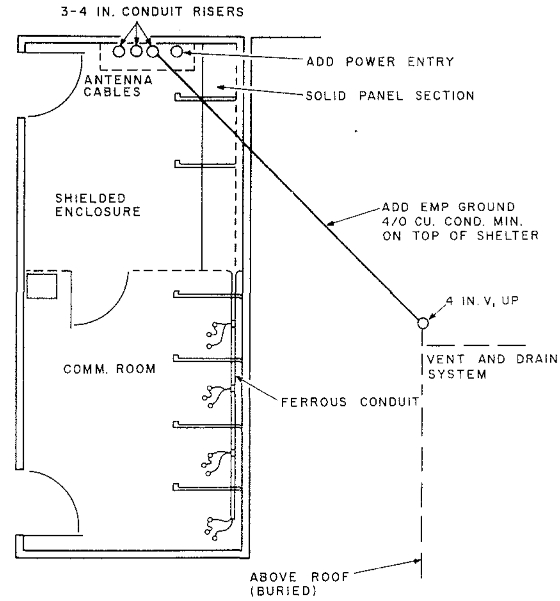


Fig. 5. Suggested layout for communications room with remote operation of equipment.

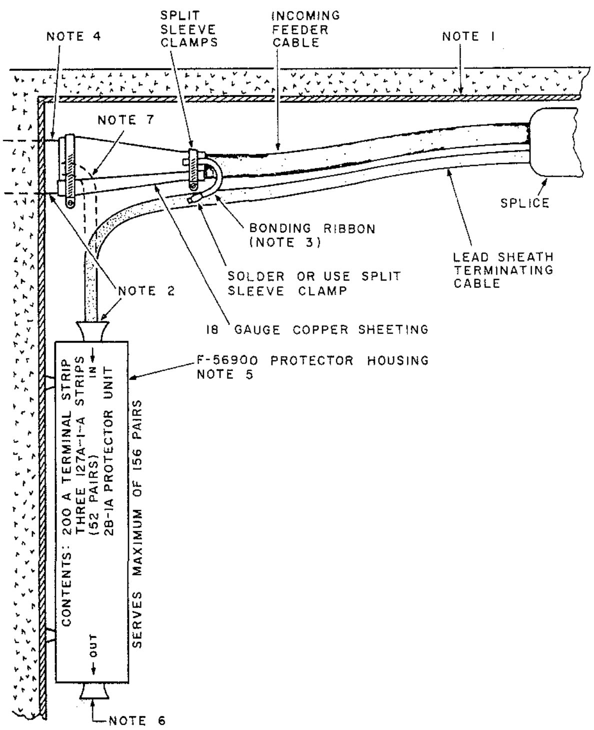


Fig. 6. This is one recommended method of protecting a telephone cable system against EMP transients. Note the heavy emphasis on shielding. The numbered notes refer to detailed construction specifications.

your equipment because they are just as susceptible to an EMP transient signal as is your sensitive transmitting and receiving equipment. A publicly-released 1970 Department of Defense publication suggests that if equipment must be used during a threat of nuclear attack, at least one set of equipment (and likely more) should be held in reserve in the event of any equipment failure. In the ideal case, ham operators should have a reserve available due to equipment failure caused by every succeeding attack.

Good grounds are very important to EMP protection, and antennas should be well grounded. But a smart operator would keep a longwire and tuner stored as if to be used for Field Day for, in any emergency, the antennas can be expected to take the brunt of the effects and may need to be replaced in the fastest time possible.

The Department of Defense publication *EMP Protective Systems* suggests several approaches which should be used if you're going to shut down for a while in anticipation of an attack. First, you should open the master power switch at your service entrance. Second, all circuit breakers should be opened and all critical equipment should be turned off or disconnected.

When the equipment and power are to be restored, all circuits should be checked for arc-overs or damage before power is restored. Be sure to disconnect telephone and cable television connections, because the advice indicates that there

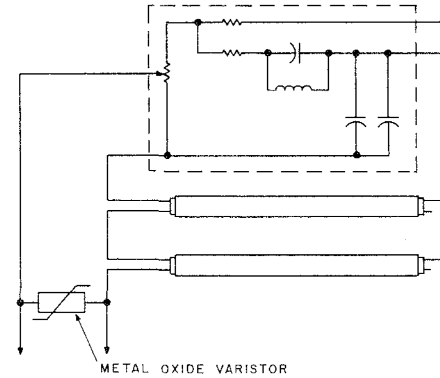


Fig. 7. This is a typical varistor installation applied to a fluorescent lighting circuit.

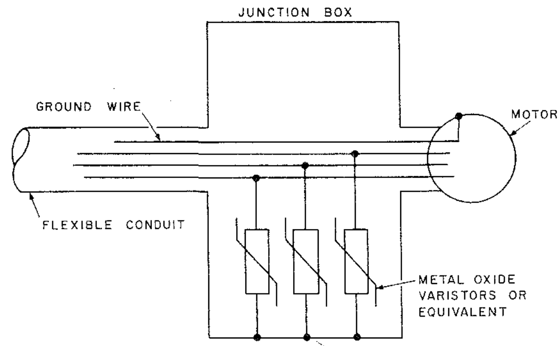


Fig. 8. This is a suggested circuit for EMP protection of a 3-phase, 4-wire motor using metal-oxide varistors (MOVs) connected between each hot wire and ground.

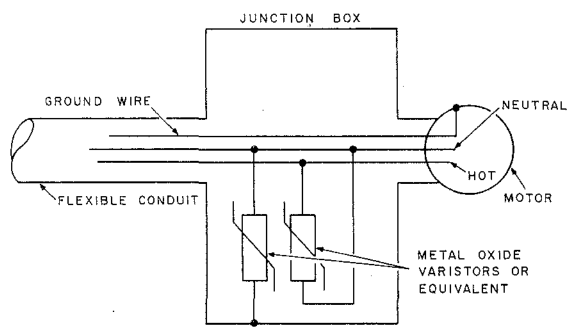


Fig. 9. Single-phase motor protection using MOVs between hot wires and ground.

could be a problem with *any* wire coming into your home. Since the EMP energy in long overhead wires can be extremely hazardous, be sure people stay away from these wires during a time of possible attack.

If you *must* have some radio equipment operating, dig out your old tube-type equipment and use it. Tubes are much less sensitive to high-voltage shocks and are more likely to recover. It is felt that less protective shielding is necessary for broadcast receivers with loopstick antennas or receivers with short antennas, including two-meter equipment. Again, however, because there are so many unknowns, a wise operator would most likely consider any equipment in full use to be vulnerable.

More advanced EMP protective measures which allow more operating versatility also have been published under the name of the Defense Civil Preparedness Agency and may be obtained from the Federal Emergency Management Agency in Washington, DC (ask for publication TR-61-B). These approaches to the problem center around the use of gas-gap arrestors, metal-oxide varistors (MOVs), coaxial tee protectors for antenna cables, and improved grounding. Some of their suggestions are described here, so you can start on your protection right away. The approach requires some expense and would be used if you would anticipate operating during a nuclear threat.

Improved grounding of a tower is extremely important for supplying a low-impedance path to ground for EMP current. The suggested way to accomplish this is shown in Fig. 1. The tower should be connected to the ground rods using 4/0 wire.

An alternative is to install 20 radials about 12 to 18 inches below the surface, using ½-inch copper tubing. The approach could get very expensive at today's copper prices but would provide an undisputably super ground for your vertical. Be sure to connect the outside of your antenna feed cable shields to the ground. Any control cables going up the tower should be shielded in threaded conduit so there is a perfect conductive shield all along the line.

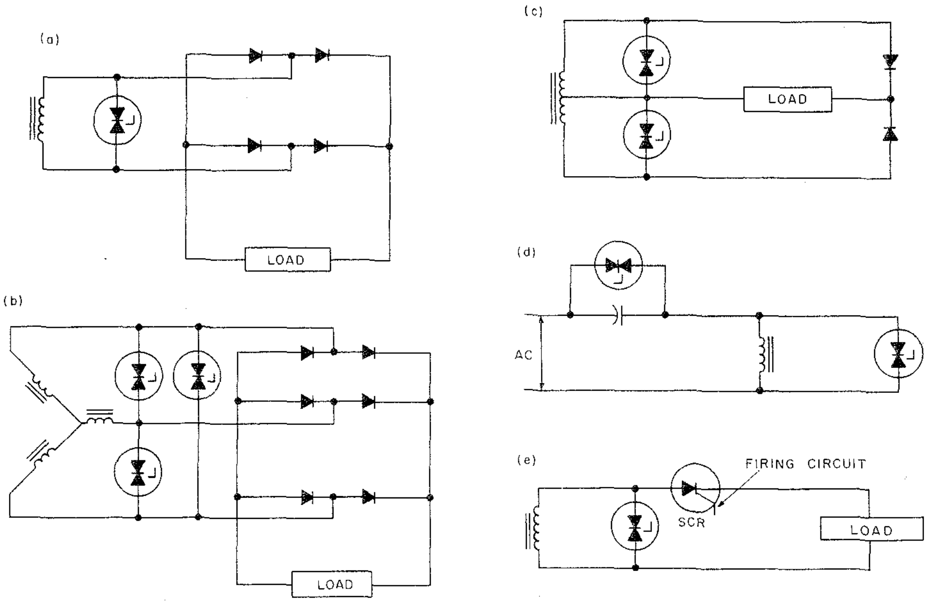


Fig. 10. Various EMP protective circuits for several typical circuits.

A particularly sensitive part of an antenna circuit is a balun at the antenna feedpoint. The best way to protect a balun is to provide "zero reaction time" gas-gap arrestors in parallel with all balun capacitors and inductors. Be sure to have the breakdown voltage of the gas gap higher than that which you would expect under normal operations, even under unusually high swr conditions. Gaps can have breakdown voltages ranging from 220 volts to 30 kV and have current ratings ranging from 3,000 Amps on up.

The amount of time that any one gap arcs over is a factor to be considered when selecting the gap. Almost any gap can sustain a large number of low-current arc-overs, but only a few very-large-current arc-overs during its life. The specifications for each gap should be consulted if it is also to handle lightning-arresting chores in addition to EMP protection. Also, most gaps capable of EMP protection are labeled as such.

The characteristic capacitance of each gap is of

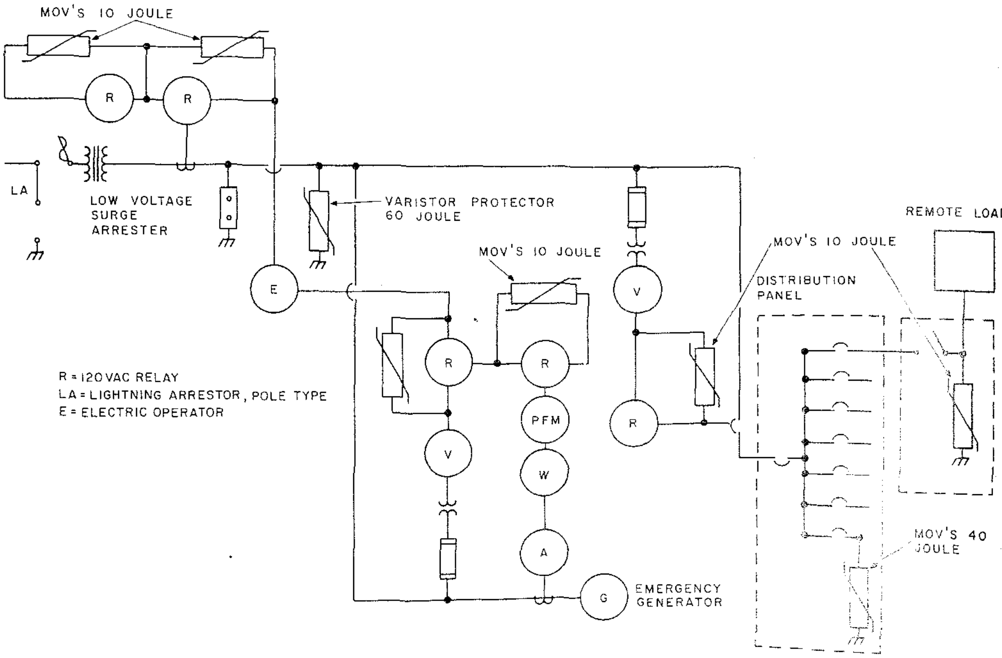


Fig. 11. Full-blown EMP protection for supplying power to communications equipment.

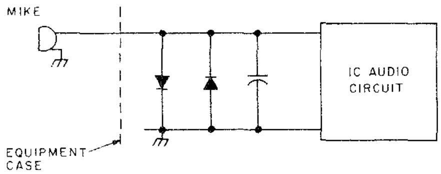


Fig. 12. Switching diodes may be used to protect very short wires. Use 1N3653s and a 0.1-μF, 500-volt capacitor.

considerable importance in rf circuits since the interelectrode capacitance between gap electrodes can cause additional capacitance to be put into the circuit along with the gas gap. This capacitance can be on the order of 2 to 15 pF or more, depending on the type of gap. The capacitance can be reduced by connecting two gaps in series. If you use that approach, be sure to put a 1-megohm or higher resistor (about 1 Watt) across each gap to equalize the voltage between gaps. Keep in mind, too, that connecting two gaps in series roughly doubles their breakdown voltage. An example of the use of gas gaps in an antenna balun is shown in Fig. 2.

At the transmitter or receiver, you may use a gas gap or tee protector as shown in Fig. 3. The diode shown here is a silicon type. While this diode has a fast reaction time, it may not be able to sustain the needed current, and should be preceded by a gas gap at a point closer to the antenna. Fig. 4 shows a gas gap connected in a transmitter circuit.

If you want to go first class and prepare the entire shack (Fig. 5), you could be in for a very expensive project, which may not be necessary if you can shut down your equipment as discussed above. However, if you wish to take that step, the FEMA recommends that the shack should be *completely encased* in 18- to 26-gauge galvanized sheet metal! To provide complete protection, the treatment includes the door and ventilation facilities. The sheet metal should be folded at the seams and soldered, with a strip of tinned-metal tape covering the seam.

Telephone landlines should be brought into the shack via 50 to 300 feet of conductive conduit which is welded to the enclosure at the point of entry. The lines should be terminated in gas gaps, metal-oxide varistors, or both. Fig. 6 shows an example. Even your lighting system should have MOV protection as shown in Fig. 7.

Ac power supply lines should have MOVs at all critical points. FEMA recommends that MOV ratings should exceed the stored inductive energy of the preceding transformer and also should exceed the no-load transformer current. Typical varistors have ratings of 40 joules (some are in the range of 10 to 200 joules) and should be installed at 40 joules per phase of the ac line. Four 10-joule varistors connected in parallel will provide the needed 40-joule protection. Electrical distribution boxes and control boxes, of course, should be thoroughly shielded. FEMA recommends that doors and openings should be fitted with rf-shielding gaskets and conductive epoxy.

Don't forget the ventilation system, where all motor wires and switches should be thoroughly shielded and protected with MOVs. Some additional circuit protection approaches may be seen in Figs. 8 through 12.

Of particular importance is the emergency generator to be used. All important wiring should have MOV protection. Shielded conductors should be used for best results and the shields should be grounded. ■

Acknowledgement
The basis for Figs. 1 through 6 and 8 through 11 is *EMP Protective Measures*, Defense Civil Preparedness Agency, 1976.

EMP Protection Equipment Sources

Some EMP protective devices are not easily obtained. I have found that even a local distributor cannot always obtain information about them. Following is an updated list of sources. Those with asterisks (*) have expressed their interest in selling the equipment by sending me information when I specifically requested information about EMP protection.

*C. P. Clare Co. 3101 West Pratt Avenue Chicago IL 60645	Gas gaps and other transient protectors
Dale Electronics, Inc. Box 609 Columbus NE 68601	Gas gaps and other transient protectors
*Emerson and Cuming, Inc. 869 Washington Street Canton MA 02021	Conductive adhesives Rf gaskets Rf shielding
*Fischer Custom Communications Box 581 Manhattan Beach CA 90266	Coaxial tee protectors
General Electric Company Electronic Comp. Sales Operation 1 River Road Schenectady NY 12306	Metal-oxide varistors (MOVs)
General Semiconductor Industries 2001 W. Tenth Place Tempe AZ 85281	Gas gaps and other transient protectors
*Joslyn Electronics Systems 6868 Cortona Drive Goleta CA 93017	Gas gaps and other transient suppressors
Lectro Magnetics 6056 W. Jefferson Blvd. Los Angeles CA 90016	Rf shields
E. A. Lindgren and Associates 4515 N. Ravenswood Avenue Chicago IL 60640	Rf shields
Ray Proof Corporation Keeler Avenue Norwalk CT 06856	Rf shields
*Shielding Technology, Inc. (Division of Chomerics) 970 New Durham Road Edison NJ 08816	Conductive adhesives
Technical Wire Products 129 Dermody Street Cranford NJ 07016	Rf gaskets and shielding
*Technit (EMI Shielding Division) 320 North Nopal Street Santa Barbara CA 93103	Rf gaskets and shielding
Topatron, Inc. Box 967 Costa Mesa CA 92627	Rf gaskets and shielding
Transtector Systems 532 Monterey Pass Road Monterey Park CA 91754	Transient suppressors