

Emcomm for the Apocalypse

Thinking the Unthinkable;

Preparing for the Worst:

Electro-Magnetic Pulse and

Emergency Communications

-- Vacuum Tubes Redux?

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- Deputy Communications Lead, New York Red Cross, September 12 – 21, 2001 (“9/11”)
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- x Liaison Officer, San Francisco ACS [RACES]
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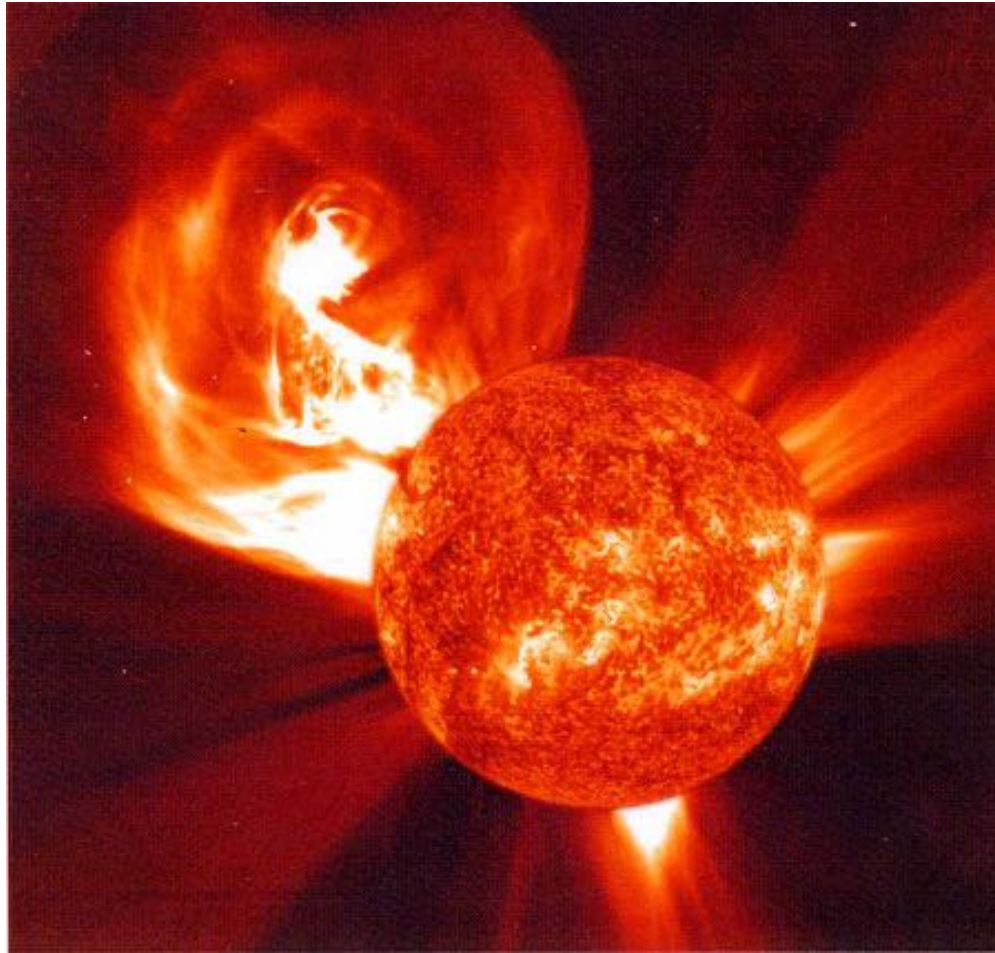
Including the AMMO Can Faraday Shield

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The Sun (on a Bad Day)



Mankind sometimes has a Bad Day
as well



The Irish Potato Famine



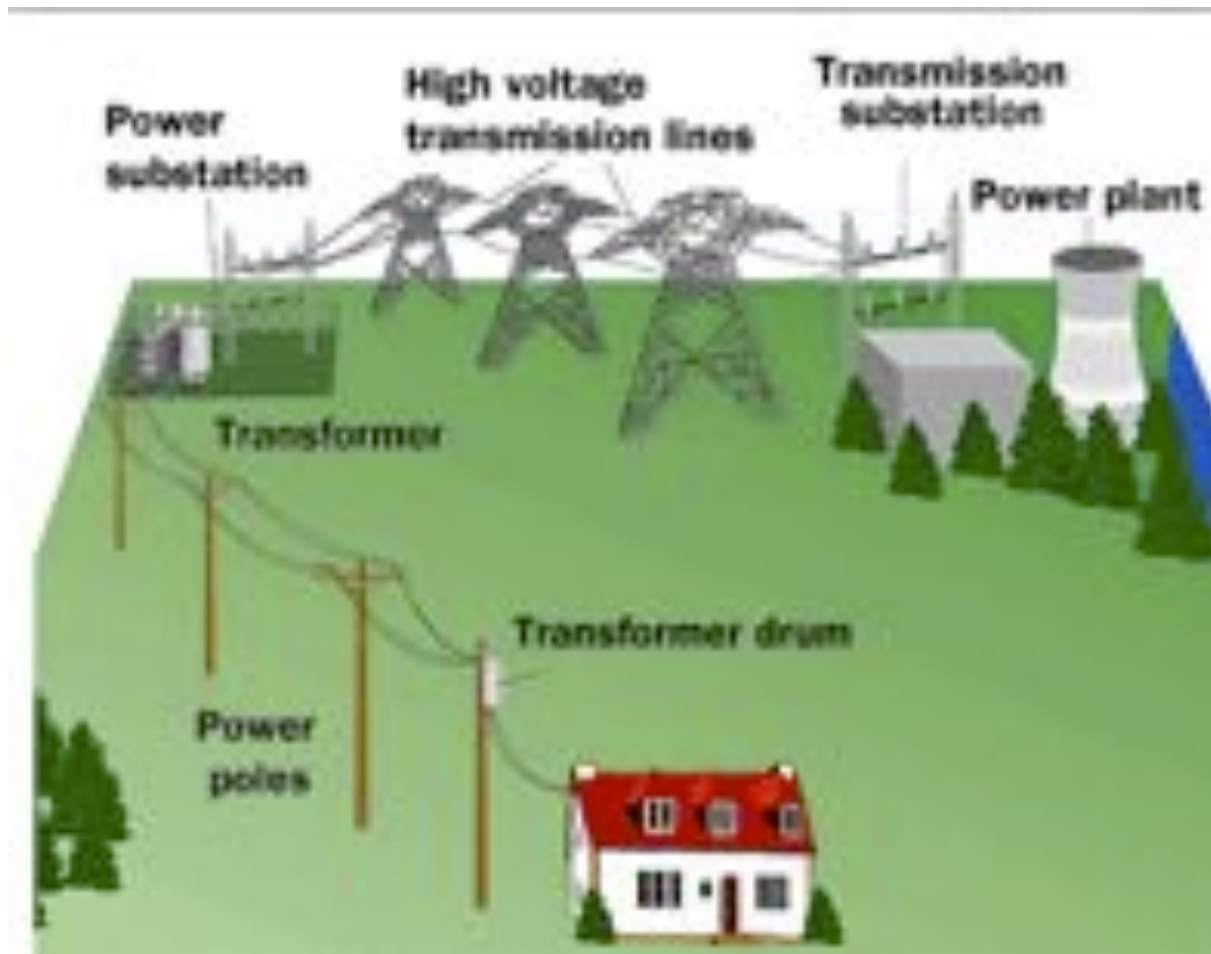
Monoculture, challenged, failed.

The American Power Grid



As shown by night-time illumination.

Power Distribution: Don't those Long Lines look like Antennas?



Typical Modern Electronic Device



A Yaesu FT-857 Amateur Radio Transceiver.

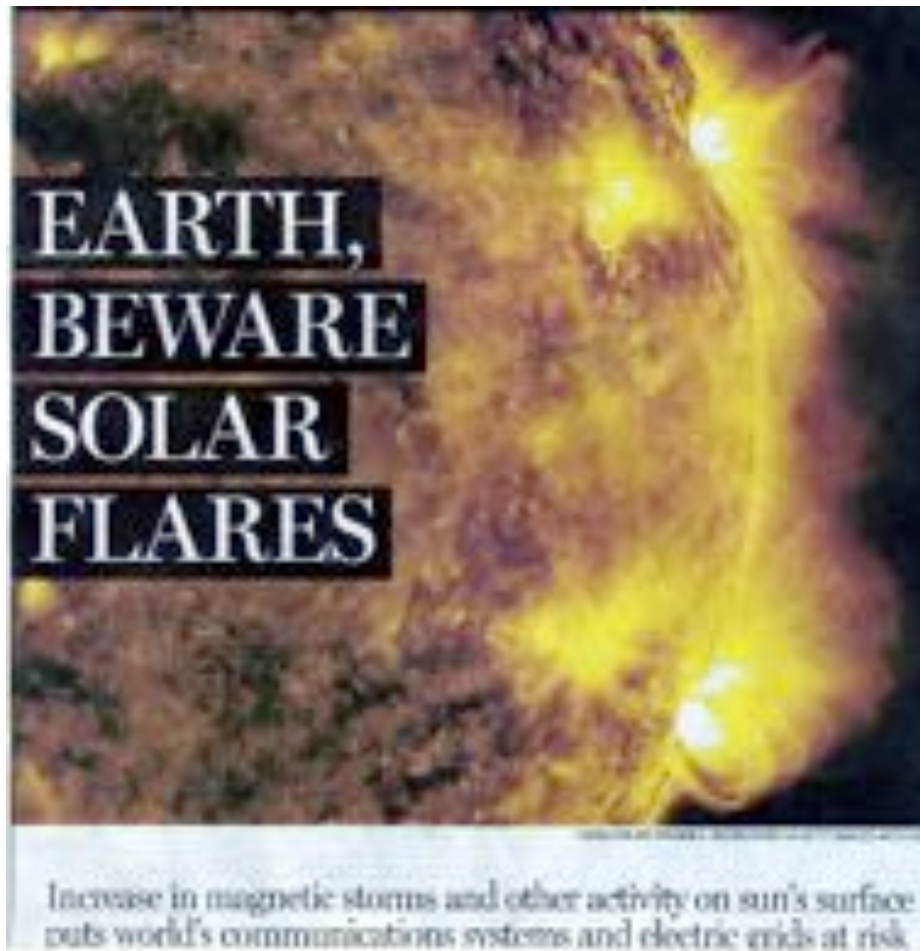
Our Civilization-wide Monoculture:

- Everything we do now is Electrical, Electronic and Digital.
- Our lives depend on Electrical, Electronic and Digital Devices: Electricity is the Foundation of our Logistics, Operations, Finance and Communications.
- Our Communications rely on Solid-state Devices, as does Industrial Control.
- *So, what could possibly go wrong?*

Two Threats: Nature and Man

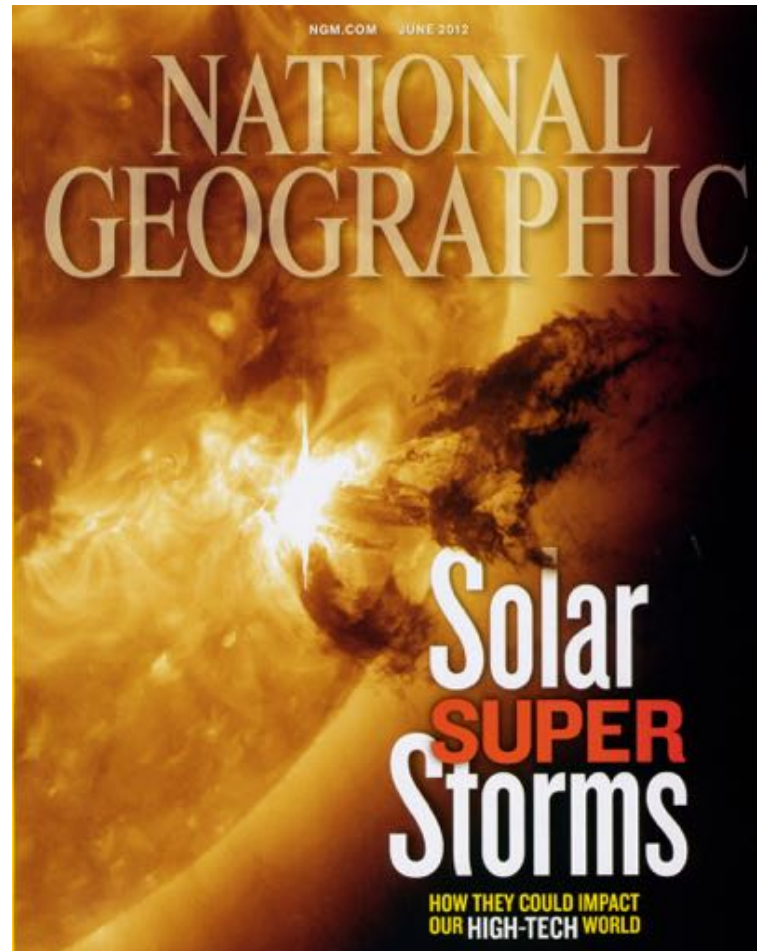
- Electro-Magnetic Pulse (EMP) can come from the **Sun**, by way of a Coronal Mass Ejection (CME).
- Electro-Magnetic Pulse (EMP) can come from an high altitude **Atomic Blast**.
- Both of these Events are of Unknown (Low?) Likelihood.
- **Either of these Events could end our Way of Life because of our Electrical Monoculture.**

Risks of Nature



A Recent Coronal Mass Ejection

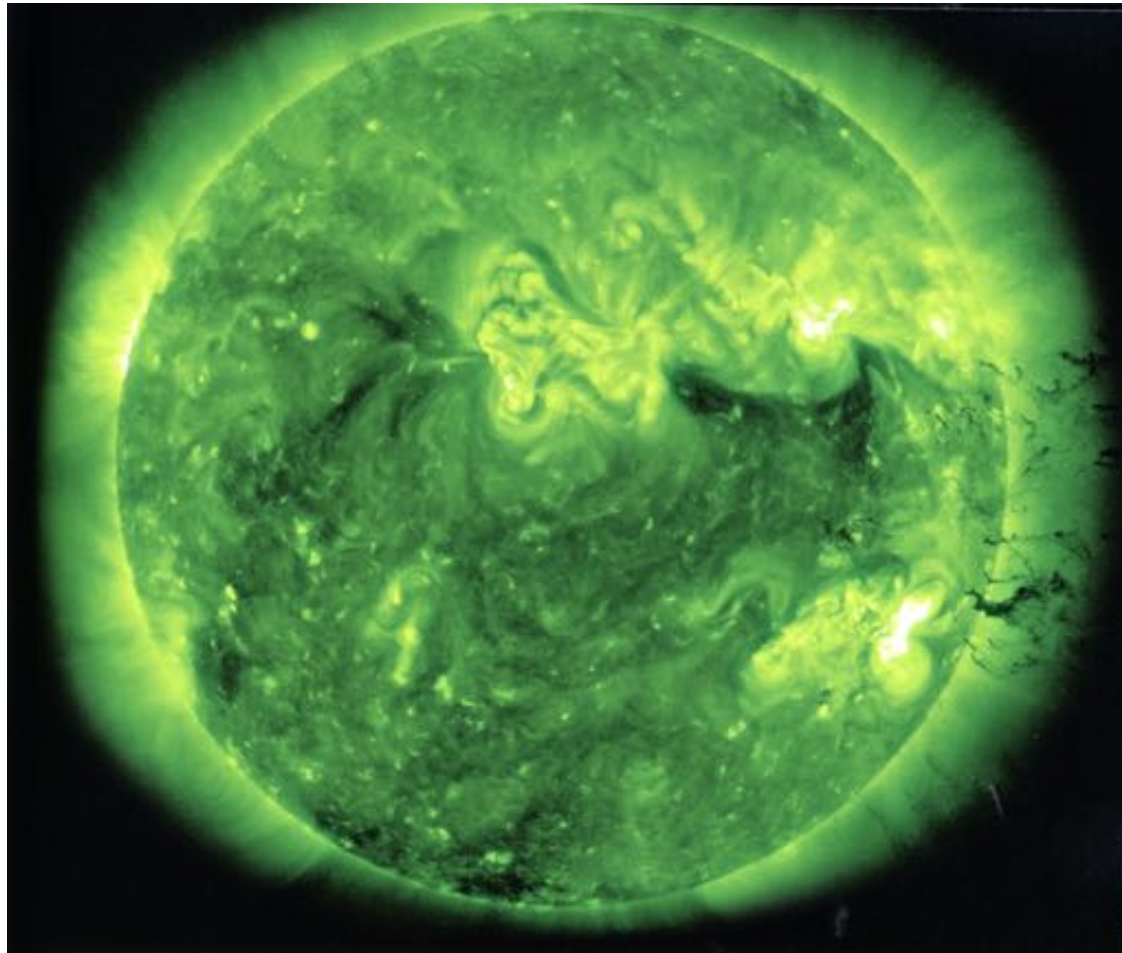
>>>CME >>>



National
Geographic
June, 2012

June 7, 2011

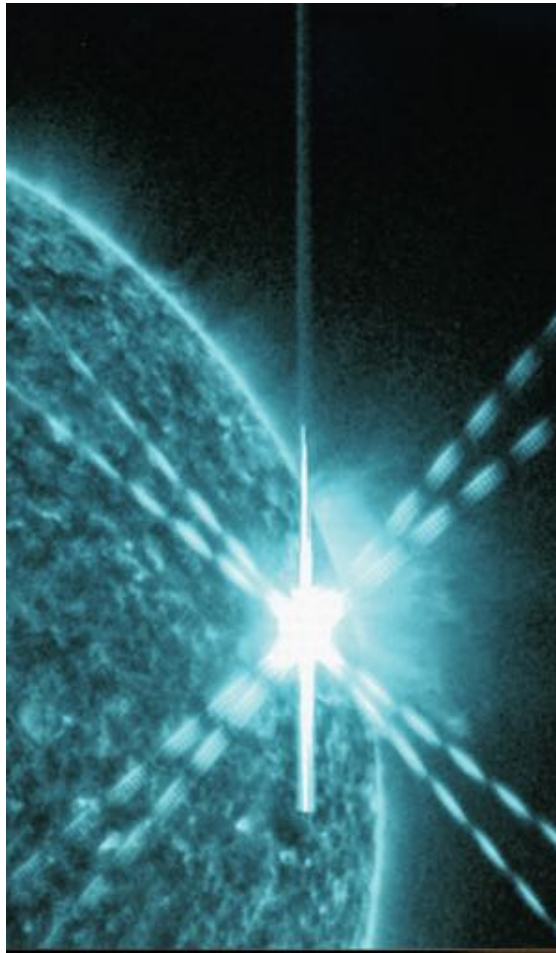
– an increasingly active Sun



<<< CME

A Recent X-class Solar Flare

-- It Overloaded the NASA Sensor



CME Consequences:

- 1859 experienced CME effects on Telegraph Lines: they could operate without other power (The Carrington Event).
- Minor CME events have taken out power grids, *e.g.*, Quebec Province in 1989.
- A major CME event could take down most, maybe all of the U.S. power grid by destroying the power transformers; it would take years to replace them.

EMP Consequences:

- An atomic weapon above the ionosphere generates ionizing radiation that creates radio frequency emissions from ionospheric electrons ($E = MC^2$).
- This **FLASH** of radio frequency energy is strongest between One Megahertz and Ten Megahertz, and extends to 100 MHz.
- **EMP is strong enough to destroy all electronics connected to a wire (antenna or not, *e.g.*, power cords, cabling).**

Electromagnetic Pulse and Its Implications for EmComm

Another look at nuclear EMP and how to maximize the likelihood of equipment survival.

H. Robert Schroeder, N2HX

QST, Nov. 2009, p. 38

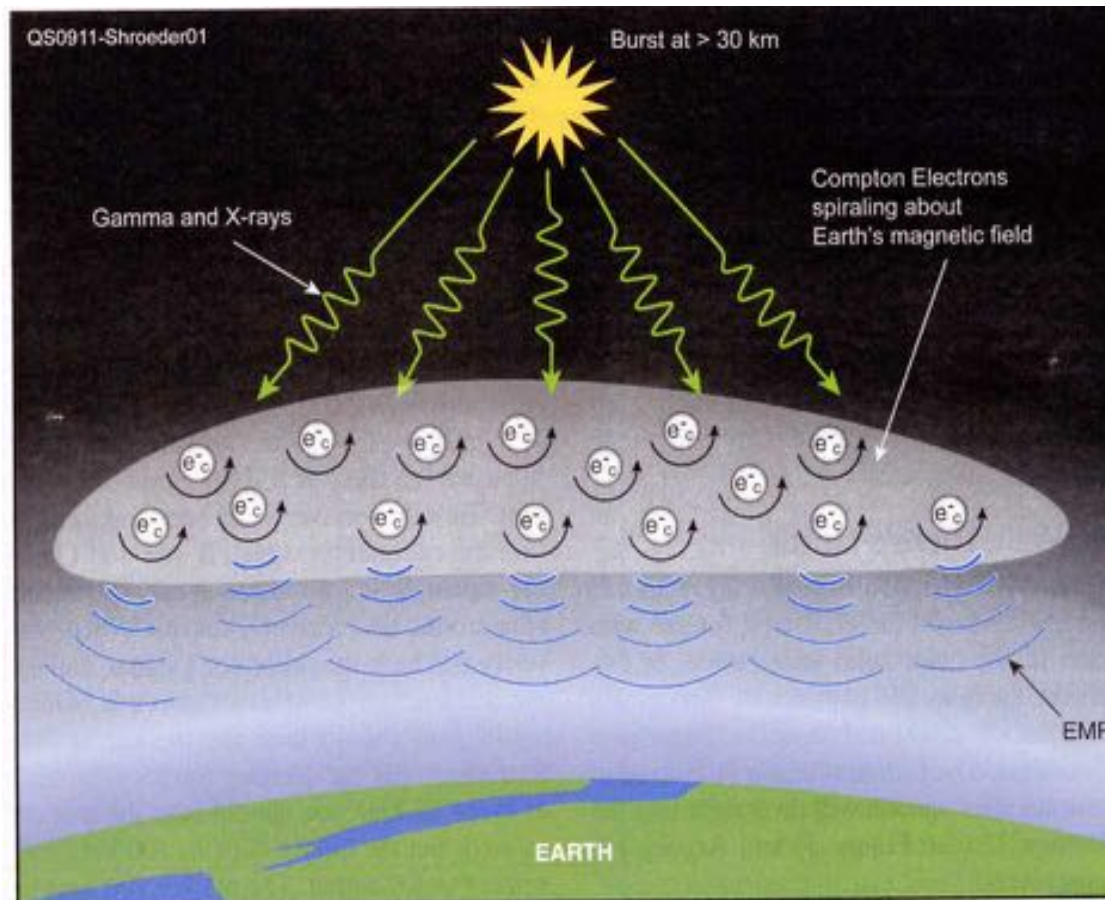


Figure 1 — Diagram of the effects that result in the generation of a nuclear EMP. High bursts can result in EMP covering the continent, with few other effects on the surface.

EMP Radiation >

< EMP Radiation

CME and EMP Effects Compared:

- A CME event **surge** will eliminate electrical power for a long time, maybe years. Nothing powered by line current will work. All long-line related devices will be at risk, *e.g.* telephones.
- An EMP radiation **flash** will create in nano – seconds high voltages at the ends of even small wires, let alone long antennas tuned to less than 100 MHz, *e.g.* Yagis and dipoles. Nothing electronic will work (unless shielded).

EMP Effects Pattern



Source: Nuclear Environment Survivability,
U. S. Army, report AG-A276230 (1994)

The Order of Magnitude

- “EMP in a 300 foot run of wire could be thought of as **40,000 volts, at 1,000 amps** flowing for 1 millionth of a second.”
 - Source: Defense Civil Preparedness Agency

Amateur Radio in Disaster Recovery

- **FEMA Administrator Craig Fugate** described the Amateur Radio operator as “the ultimate backup, the originators of what we call social media” (May, 2011) ... “I think that there is a tendency because we have done so much to build infrastructure and resiliency in all our other systems, we have tended to dismiss that role[‘the ultimate backup.’] ‘When Everything Else Fails’ Amateur Radio oftentimes is our last line of defense....[W]e get so sophisticated and we have gotten so used to the reliability and resilience in our wireless and wired and our broadcast industry and all of our **public safety communications**, that we can never fathom that **they’ll fail. They do. They have. They will.** I think a strong Amateur Radio community [needs to be] plugged into these plans.
- ***... [W]hen you need Amateur Radio, you really need them.***”

When Everything Else Fails?



When All Else Fails: EMP & CME

- An EMP or CME event will cause massive **social disorder, starvation** and **disease**. Strong local social networks will promote survival.
- EMP and CME destroy communications equipment radio amateurs rely on. But communications readiness will be extremely valuable and communicators valued.
- To be useful, **equipment must be protected**.

EMP: The Faraday Shield

- A “faraday shield” can protect Radio and Electrical equipment.
- It is enough metal around an object to keep radio frequency energy out of it; it need not be solid, mesh will work.
- Foil wrapping works, a galvanized trash can or ammo can or file cabinet works; foil wrapped equipment inside a larger shield works best.
- A ground lead on a shield is an antenna; **float, do not ground, the shields.**

Cable and Tower EMP grounds

- Ground the shields of coax cable runs at the tower and at the shack entrance.
- 30 foot radials of ½ inch copper tubing, at 15°, 12 to 18 inches deep can ground voltages induced in the tower;
- Alternatively, three deep 60° ground rods to moist soil (20 feet) can ground a tower.
 - Source: Defense Civil Preparedness Agency

Stored Radios



Stored Radios



Radios Wrapped in Foil & Bagged



Insulate the Foil Wrapped Packages from each other.

Foil-wrapped HTs



Then store in an ammo can, trashcan or metal file-cabinet, insulated from it.

A Splendid Container



KA7OZO

Interior Insulation



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Insulation In Place



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It All Fits



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Actual Components

- **Solar Panel w/cables**
- **2 – VX-170 w/attachments**
- **VX-170 AA-battery pack**
- **KPC-3+ w/cables**
- **FT-1500 w/attachments**

Components Protected



KA7OZO

Components Packed



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Insulate the foil-wrapped devices from each other – K6VK

Top Insulation



KA7OZO

A Protected Go-Kit



Ready to be painted.

KA7OZO

EMP: Antenna Protection

- EMP is a nano-second voltage pulse; lightning arrestors will not stop it, they're too slow.
- Metal Oxide Varistors (**MOV**s) with low clamping voltages and fast, nano-second response time can prevent an EMP pulse from getting into equipment connected to antennas.
- Powerline connections must also be protected, best with a line-isolated **UPS** and filters; this is also lightning protection.

Better your varistor MOVs blow
like this than your radios



EMP and Lightning Compared

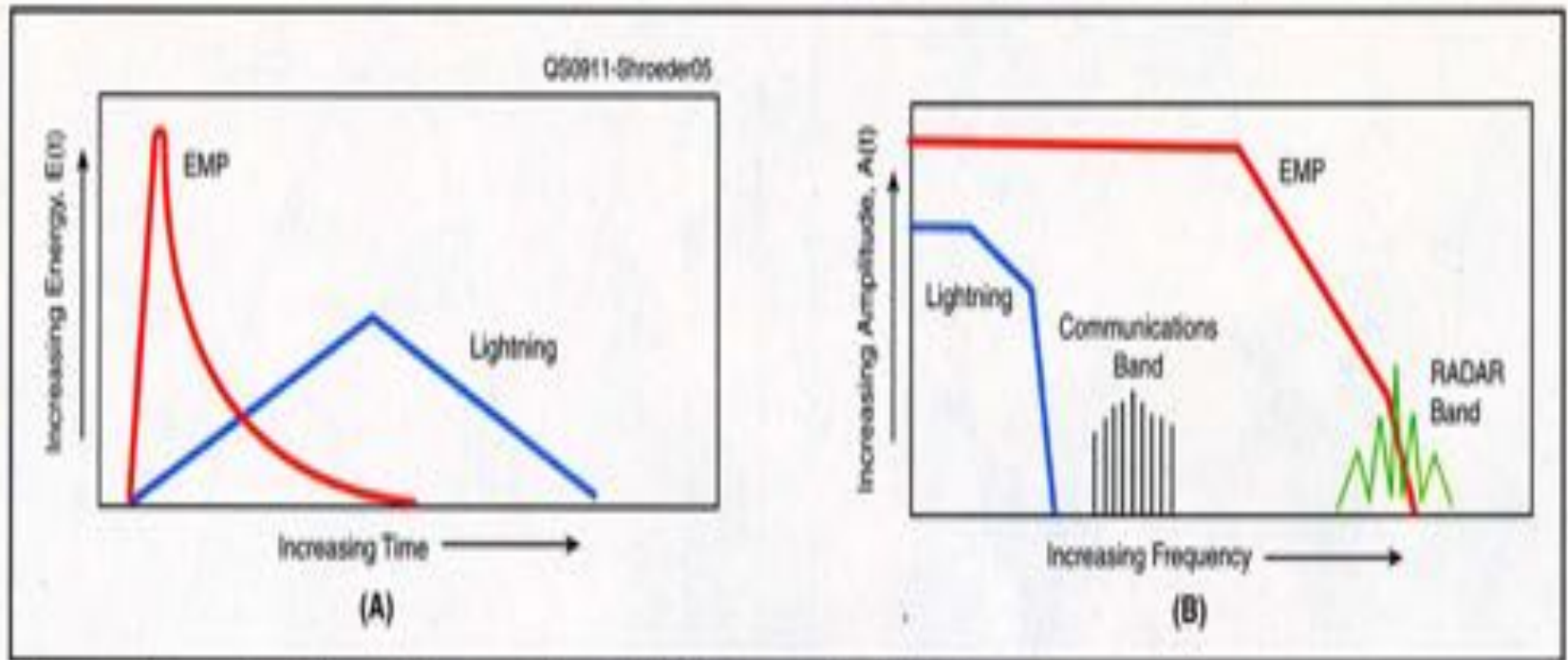


Figure 5 — Comparison of time and frequency domain of EMP compared to lightning.

EMP and Vacuum Tube Gear

- An EMP flash will fry any solid-state equipment subject to it because the chips and FETs are so sensitive (even to static discharge).
- **Vacuum tubes are unaffected**, being vacuum insulators. Vacuum tube transmitters are unaffected. Vacuum tube receivers are substantially unaffected but may lose front-end coils and components.
- Solid-state power supplies are at risk from voltages generated in the line cords.

Solid-state RF circuit, direct EMP risk to the FET

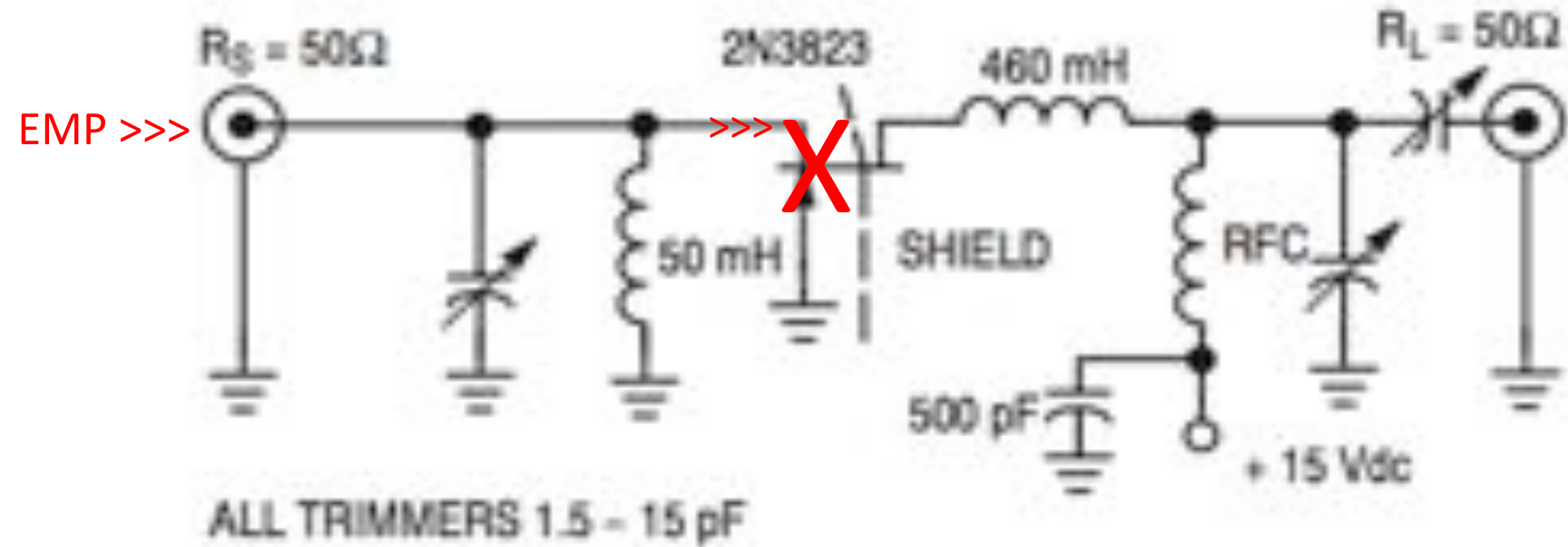
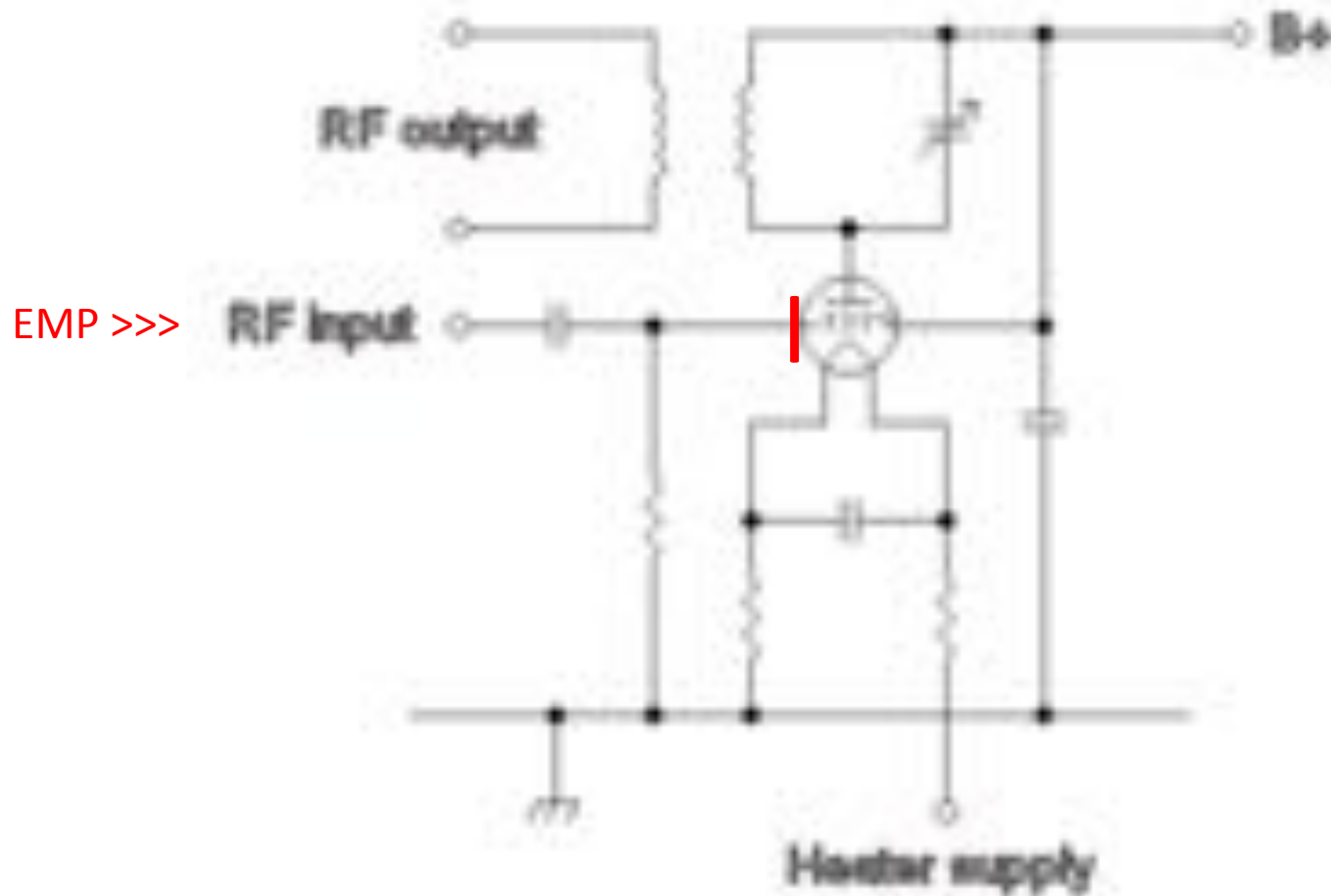


Figure 1. 200 MHz Common Gate Amplifier

FET RF circuit

www.freescale.com/files/rf_if/doc/app_note/AN423.pdf;

Vacuum tube RF stage, EMP risk only to the grid resistor and capacitor:



Save Your Heathkits!!

- Vacuum Tube Amateur Radio Receivers and Transmitters will likely survive EMP, as long as there are no leads connected.
- Keeping Spare Parts for Receiver Front Ends, etc., would be Prudent.
- Powering Vacuum Tube Filaments will quickly drain Batteries, especially Transmitters.
- Solar Battery Recharging will keep them going.

EMP and Lightning Protection

- Grounding protects against lightning but ground wires act as EMP antennas.
- Lightning and electrical grounds are required for safety, often by law.
- EMP protections must supplement but not defeat lightning and electrical protections.
- Most lightning damage comes from power line surges so EMP/CME protections are consistent.

EMP and VHF/UHF

- An EMP flash conveys little energy above 100 MHz.
- Handi-talkies, hand-held transceivers (HTs) even with rubber-ducky antennas are at little risk.
- **But:** VHF and UHF repeaters are unlikely to survive EMP effects on their receivers and power supplies.

EMP, CME and Power for Radios

- After an EMP or CME event, all electrical power will be down, maybe for a *very* long time.
- Communications will depend on emergency power.
- Generators will soon run out of fuel and soon none will be available.
- Solar power into batteries will work best.

Solar Power in an EMP, CME Event

- EMP will fry solar panels, but a wire-mesh shield can protect them (costing efficiency), if leads are also shielded and equipment protected with MOVs.
- A CME surge will likely destroy solar systems connected to the power grid.
- A solar system kept in a faraday shield and deployed after an event is the best emergency power source.
- Solid-state equipment requires less power than vacuum tube equipment but vacuum tube equipment is more likely to survive.

EMP, CME and Batteries

- Rechargeable Batteries will provide emergency power for communications, etc.
- Solar power can recharge batteries, as can other sources of electricity.
- Batteries can be protected in faraday shields from EMP effects.
- Batteries connected to a charger at the time of an EMP/CME event may be at risk.

EMP, CME & Disaster Preparedness

- Strengthen local social networks from Church to CERT; community enables survival.
- Foster family survival with stored water, food medicine and weapons *and knowledge*.
- Store unused equipment and a back-up solar power system in faraday cages (batteries separately).
- Protect all antennas with MOVs and all power supplies with isolated UPS capacity.

Who Will You Talk To?

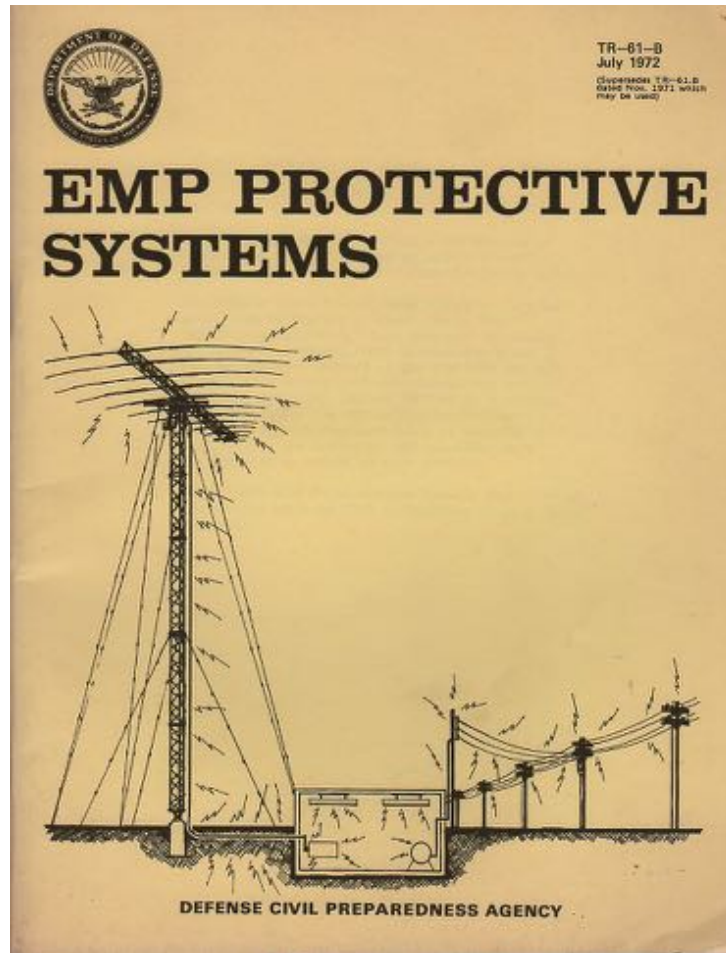
- Your gear is protected but. . .
- Talk to your friends and get them to do it too
- Use extra gear for this project
- Rotate batteries & recharge on a decent schedule
- Stage protected kits at various sites
- Mark appropriately for easy locating

De David Kidd, KA7OZO

Further Investigation

- The best single source regarding EMP and Radio is Jerry Emanuelson at www.futurescience.com/emp/emp-protection.html .
- For the science, go to www.en.Wikipedia.org/wiki/Electro_magnetic_Pulse.
- For Amateur Radio, see the 1986 QST articles that suggest considerable surviveability: www.jumpjet.info/CEM/04/Electromagnetic_Pulse_and_the_Radio_Amateur.pdf and H Robert Schroeder, N2HX, *Electromagnetic Pulse...*, QST, Nov. 2009, p. 38
- For faraday cage construction, see also: www.unitedstatesaction.com/electrical-threat.html

Guidelines for Installations



Defense Civil Preparedness Agency, 1972

Antennas, Equipment, Telephone, and Power EMP Protections

TABLE OF CONTENTS	
	Page
Foreword	i
General	1
CHAPTER I	
Antennas and related connections	3
1. Ground rod counterpoise	3
2. Grounding of cables	3
3. New conductive cables	3
4. Balun treatment	3
Coaxial tee protectors for antenna cables	10
Balun protection	11
Ground connection at tower base (typical)	12
CHAPTER II	
Communication equipment	14
1. Shielded enclosure penetrations	14
2. Receiver protection	14
3. Shielded enclosure lighting	15
4. Shield enclosure designs	15
5. Communication equipment treatment	15
Shielded box (small)	16
Shielded box (large)	17
Communication room floor plan	18
CHAPTER III	
Telephones	
1. Telephone frames	22
2. Incoming cables	22
3. Telephone lines in building	22
4. Under floor ducts	22
Telephone cable bonding method	24
CHAPTER IV	
Power	
1. Grounded transfer switch	25
2. Emergency generators	25
3. Distribution panels	25
4. Lights	26
Grounded transfer switch installation	27
Main panel protection and commercial power protection	28
Single line power diagram	29
Grounding switch for utility power connection	30
Typical gas gap protection at critical load	31

Coda

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For More Information on the AMMO Can Faraday Shield

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Make this better:

- Please send any suggestions for improvements: KV6LEE@gmail.com.
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Venue Diploma



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Forum Speaker