

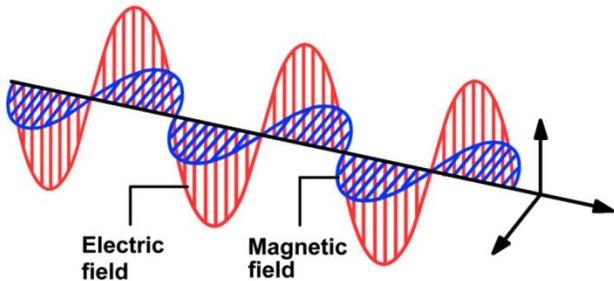
## Preparing for Electromagnetic Pulse (EMP) – Roald Peterson

### Introduction

- Imagine a World Without Electricity (after EMP)
  - No lights or infrastructure - like the Middle Ages
  - You don't know how to live in the Middle Ages
  - There is no Middle Ages infrastructure
  - Surrounded by starving, cold, desperate people
  - Worse than the Third World because...
  - Third World people know how to live without & they aren't expecting help
  - It's going to be dark for years
- Current State of American People
  - Rely on technology for everything
  - Lived far from what they need for life
  - Few people have survival skills for real world

### Physics Lesson

- Electromagnetic (EM) Spectrum

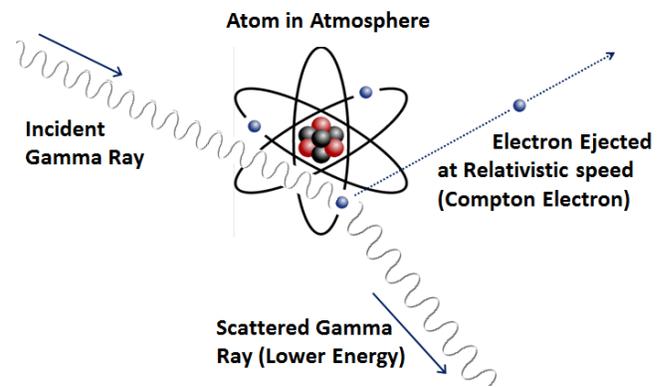


- Changing magnetic field (moving magnet) causes electric field
- Changing electric field (moving charge) causes magnetic field
- EM = Radio, Microwaves, Light, Heat, X-rays, Gamma & Cosmic rays—different frequencies
- X-rays and Gamma rays are ionizing radiation
- As frequency increases, wavelength gets shorter
- Antenna must be near size of wavelength

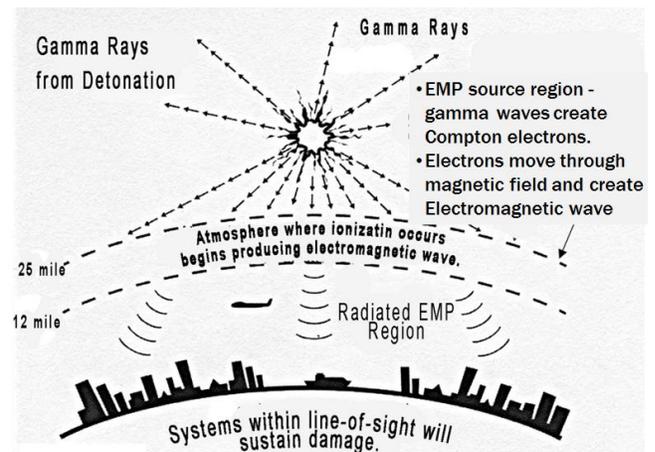
### What Is EMP?

- EMP is a burst of high intensity electromagnetic energy at radio frequencies
- 3 types of EMP - Destroy different types of devices in different ways, & are produced in different ways
  - Solar Flares/Coronal Mass Ejections (CME)
  - High altitude (above atmosphere) nuclear detonation (HEMP)
  - Other explosive & electronic devices (local EMP)
- Begins with High Altitude Nuclear Detonation

- Usually measured in kilotons (1000 tons of TNT) or megatons (million tons of TNT)
- WWII – 3.4 MT of bombs, Viet Nam – 7 MT
- Modern warheads 100s KT to MT
- 10 or fewer have more destructive power than all the allied bombs dropped in WWII
- Energy released from nuclear weapon
  - Blast: 40–50% of total energy
  - Thermal radiation: 30–50%
  - Ionizing radiation: 5% (X-rays and Gamma rays) (Ionize = separate electrons from atoms)
  - Residual radiation : 5–10%
- Compton Effect



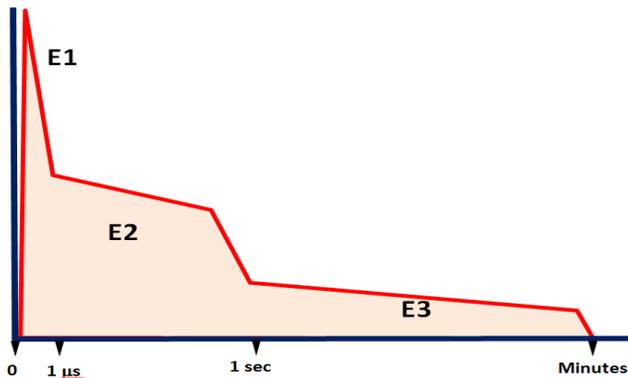
- Compton electrons move through Earth's magnetic field – generate EM wave



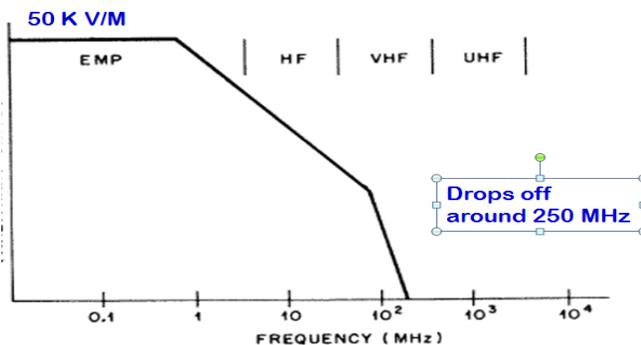
- EMP Coverage is Line-of-Sight – 300 miles altitude → covers all of US
- Intensity Varies With Magnetic Field
- Nuclear EMP has 3 components: E1, E2, and E3
- E1 produces intense EM field ~ 50,000 Volts/meter
  - Range is line of sight
  - Very fast, short, intense pulse – ends in 1 μsec
  - Too fast for ordinary surge protectors

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- Damages semiconductors (transistors, diodes, LEDs, microprocessors, etc.) by exceeding breakdown voltages
- Nuclear EMP E2
  - Generated by scattered gammas & Compton
  - Less energy, less intense than E1
  - Intermediate time pulse (to 1 Sec after)
  - May destroy devices weakened by E1 pulse
- Nuclear EMP E3
  - Long slow pulse, 10s to 100s of seconds
  - Detonation distorts Earth’s magnetic field. As field restores, induces currents in power lines
  - Damages transformers and other components
  - Like geomagnetic storm caused by a solar flare
  - Proportional to energy yield of weapon
- Solar EMP
  - Solar flares accompanied by an increase in the solar wind or Coronal Mass Ejections (CME) may cause a Geomagnetic Storm (GMS)
  - GMS can cause an E3 type of EMP (**Not E1 or E2**)
  - Produces large currents in long electrical transmission lines, damaging transformers, etc.
  - Not dangerous to household length lines
- EMP Timing



- EMP Frequency Spectrum = 0 – 250 MHz



### Effects of EMP

- Solar EMP causes GMS, which produces large Geomagnetically Induced Currents (GIC) in long conductors - primarily DC (Direct Current), 10s - 100s of amps (Grid is high voltage, low current AC (Alternating Current))
  - Damages/Destroys Electrical transmission & generation equipment (transformers, and more)
  - If power substation fails, load transfers to others
  - Can cause cascading failures. Estimates:
    - If 2-4% of key substations fail → 60% blackout
    - If 8% fail → 100% blackout of continent
  - Few spares are available - Grid down for years
- Nuclear E3 has same effects as a solar induced GMS
  - Loss of power grid and everything it supports
  - Accompanied by E1 and probably war
- Nuclear E1 creates EM field of up to 50 kV/m
  - Field varies with distance and location
  - All metal objects, wires, circuits act as antennas
  - Fields are directional. Geometry is unpredictable
  - **Your world is run by semiconductors (transistors, microprocessors, diodes, LEDs, etc.)**
  - **High voltage destroys semiconductors**
  - Semiconductors usually low voltage devices. Most handle < 100V, some < 10V
  - High voltage enters electronic circuits via antennas (any wire) or metal traces on circuit boards and destroys semiconductors
  - Lower voltage can lock up computers → reset
  - What’s at risk – most everything using electricity
  - Cardiac pacemakers should survive (see study)

Antenna Length	Voltage Induced
1 meter	50,000 Volts
10 meter	500,000 Volts
1 foot	15,244 Volts
1 inch	1,270 Volts
15 inch laptop screen	19,050 Volts
42 inch TV	53,340 Volts
6 ft electrical cord	91,463 Volts
75 ft house electrical wire	1,143,300 Volts

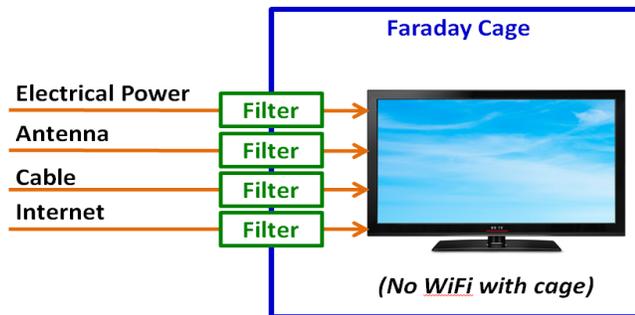
- Motor vehicle susceptibility
  - Vehicles have 30 to 100 microprocessors
  - Made to run in harsh electronic environment

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- Most vehicles are partial Faraday cages
- Immune to damage from solar storm –no fuel
- Risk? Depends on orientation, weapon, distance, parked in or out, running or not, magnetic field
- Rigorous testing not done or results unavailable
- Cars not running expected to survive
- Running cars may or may not suffer upset or damage – percentages unknown
- Nuclear E2 EMP like E1 but slower, weaker
  - May destroy devices weakened by E1

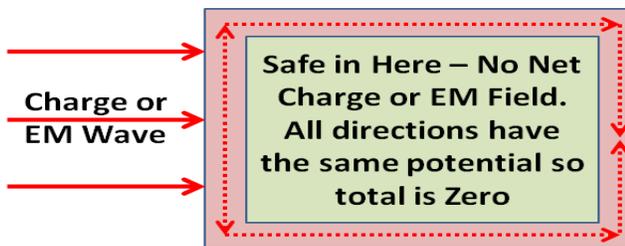
### EMP Protection

- Two types of EMP protection
  - Protect against surges induced in devices by EM field - **Use Faraday Cage**
  - Protect against surges entering via antennas (power, signal, and control cables) - **Disconnect cables (don't use device) or use EMP surge protectors (Filters that stop EMP surges)**



*Filter = Surge Suppressor (EMP Qualified, not Lightning)*

- A Faraday Cage = enclosure of conductive material. Charge is conducted throughout the material, creating a constant potential (voltage) on all sides, and zero net potential inside the enclosure.



- Cage works as long as the charge doesn't exceed ability of conductive material to carry the charge
- If screen is used, mesh size (holes) must be significantly smaller than the wavelength

Frequency	Wavelength	Wavelength	1/10 Wavelength
100 KHz	3,000 m	9,843 ft.	984 ft.
1 MHz	300 m	984 ft.	98 ft.
10 MHz	30 m	98 ft.	9.8 ft.
100 MHz	3 m	9.8 ft.	11.8 in.
200 MHz	1.5 m	4.92 ft.	5.9 in.
250 MHz	1.2 m	3.94 ft.	4.7 in.
894 MHz	33.6 cm	13.2 in.	1.32 in. (phone)
1900 MHz	15.8 cm	6.2 in.	.62 in. (phone)

- Faraday Cage Principle works without grounding. No harm in grounding – equalizes charge on cage with any other grounded devices
- Pre-built Faraday cages: microwave oven, metal tool box, file cabinet, metal cases, metal garbage can
- Use Ohmmeter (multimeter) to test for connectivity between door/lid and cage.
  1. Set for Resistance ( $\Omega$ ) testing (ohms)
  2. Set for lower readings ( $< 2000 \Omega$ )
  3. Touch probes together, note reading (0-2)
  4. Touch 2 parts of cage – reading should be nearly same
- Note – some multi-meters have beeper
- Build a Faraday Cage using metal sheeting, screen, or foil
  - Screen mesh should be smaller than smallest wavelength (1/10 wavelength or smaller)
  - All parts of enclosure must electrically connected (sides, top, floor, door)
  - Keep metal parts of objects inside from touching cage
  - Copper, Aluminum, galvanized steel good. Make a box and add screen – or make a pouch
  - Hard part is door and gasket. Make your own RF gasket by rolling screen under itself
- Poor Man's Cage testing – put radio inside
  - 100 MHz – FM radio (87.5 – 108 MHz)
- For better protection, use a cage within a cage - Wrap in aluminum foil, then put in a cage
- Filters (Surge Protectors) only needed for operating equipment
  - Usually used in conjunction with Faraday cage
  - Need to select filters for your specific needs - Power (voltage, current) and signals (radio, TV, network, phone)

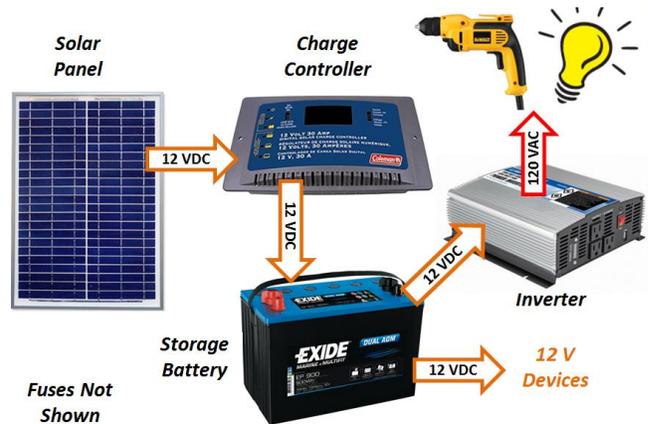
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- Need EMP surge suppressors, not lightning
- Study the subject and get advice from engineer
- In most cases it's easier and more reliable, and possibly cheaper to just shield spare equipment
- Move more into cage, have fewer filters

### Preparation for EMP

- EMP Preparation Strategy
  - EMP is one of many threats. Preparation should fit in with and augment your other preparation
  - Prepare for a total loss of infrastructure
  - Nationwide versus local or regional (**no help**)
  - Effects likely to last for years
  - Associated with nuclear war or societal collapse
  - Plan and implement a **low-energy lifestyle**
  - Avoid single point of failure – have multiple solutions for everything possible
- If you want the convenience of electricity:
  - Decide what electronics you want to use
  - Protect electrical devices (originals or spares)
  - Provide a protected source of electricity
- Have plans – Practice them
- You probably don't have time, resources, and storage space to get everything
  - Prioritize your preparations – essentials first
  - Research what others are doing, and why
  - Counsel with your spouse about what you need
  - Counsel with the Lord
- Augment your current preparations for EMP
  - Consider the following areas with the idea of years long, total collapse of infrastructure: Food, Cooking, Food prep, Renewable food supply, Water, renewable water, Garden water, Fuel for cooking and heating, Sanitation, Tools, Protection, Medical & Health, Entertainment, Education, Light, etc.
- Communications
  - Receive-only comm for warnings and info: AM/FM radios, weather radios, satellite radio, Shortwave (HF) radio – learn to use it now
  - Two-way communications: Amateur radio (HF for long-distance), FRS and GMRS radios (1-26 miles)
  - Arrange with family for a message box: Set times and places for messages and meeting, Discuss plans for getting home or to safe places

- Transportation - Keep supplies and pack in car – be ready to walk
  - Plan escape and alternative routes before hand
  - Have maps – national & local change)
  - Plan a lifestyle with minimal travel
  - Fuel supplies will disappear; save for emergencies
  - Get bicycles, tires, tubes, **slime**, extra bicycles
  - Get air pumps and extra air pumps
  - Consider similar bicycles so you can cannibalize
  - Consider wheelbarrows with solid tires
  - Consider garden carts – for food, water, and fuel
- Electrical Power
  - Store lots of batteries – when you need them they won't be for sale (hurricane Frederick)
  - Consider solar power system – one or more panels



- Have rechargeable batteries and chargers that work with 120 VAC and 12 VDC
- Have and protect spare panels, charge controllers, inverters if you keep your system operational
- Analyze how much power you really need and Have extra storage batteries for dark times
- Other sources of electrical power: Gas or diesel generators – require fuel, Wind power – for South Weber residents
- Study before you buy – learn how, save money
- Preparation At Work - 1/4 of your life at work - 25% chance of EMP while at work
  - Have plans to communicate and get home - Alternative ways home, know what to do
  - Protected two-way radio with extra battery
  - In some scenarios, if you can't get home in time, may have to shelter your work place for days

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- Have supplies at work or in car (food, water)
- Have walking shoes and appropriate clothing
- Have protected radio – AM, FM, Weather, HF
- EMP Preparation for Car
- EMP Not Isolated Event - Multi-disasters are increasing - Fukushima – quake, tsunami, reactor meltdown
  - EMP will be accompanied by infrastructure collapse, societal breakdown (no law), panic, desperate people, starvation, disease, death
  - EMP probably not the only attack vector– other attacks possible including nuclear, chemical, biological

### More Information

- US EMP Commission Reports:  
<http://www.empcommission.org/reports.php>
- DNA EMP Course Notes:  
<http://www.dtic.mil/dtic/tr/fulltext/u2/a058367.pdf>
- Future Science EMP Pages:  
<http://www.futurescience.com/emp/>
- Many Documents Used by Military. Search on “EMP” & “Electromagnetic Pulse”:  
<http://www.dtic.mil/dtic/>
- EMP Effects on Pacemaker  
<http://www.dtic.mil/dtic/tr/fulltext/u2/a242990.pdf>
- Metatech EMP Reports  
[http://web.ornl.gov/sci/ees/etsd/pes/ferc\\_emp\\_gic.html](http://web.ornl.gov/sci/ees/etsd/pes/ferc_emp_gic.html)
- Mil Hbk for Grounding Bonding Shielding 1987 vol1  
[https://www.wbdg.org/ccb/FEDMIL/hdbk419a\\_vol1.pdf](https://www.wbdg.org/ccb/FEDMIL/hdbk419a_vol1.pdf)
- Mil Hbk for Grounding Bonding Shielding 1987 vol2  
[https://www.wbdg.org/ccb/FEDMIL/hdbk419a\\_vol2.pdf](https://www.wbdg.org/ccb/FEDMIL/hdbk419a_vol2.pdf)
- Mil Hbk 1195 - RF Shielded Enclosures  
<http://www.wbdg.org/ccb/NAVFAC/DMMHNAV/1195.pdf>
- Mil Std 188-125-1 - HEMP Protection for C41 Facilities  
[http://www.wbdg.org/ccb/FEDMIL/std188\\_125\\_1.pdf](http://www.wbdg.org/ccb/FEDMIL/std188_125_1.pdf)
- EMP Electronic Analysis Handbook 1973  
<http://www.dtic.mil/dtic/tr/fulltext/u2/918275.pdf>

- EMP Electronic Design Handbook 1973  
<http://www.dtic.mil/dtic/tr/fulltext/u2/918277.pdf>
- EMP Handbook for AF Comm Service – 1976  
<http://www.dtic.mil/dtic/tr/fulltext/u2/a060435.pdf>
- EMP Hbk for Electric Power Systems - Stanford 1975  
<http://www.dtic.mil/dtic/tr/fulltext/u2/a009228.pdf>
- Nuclear Matters Handbook  
[http://www.acq.osd.mil/ncbdp/nm/nm\\_book\\_5\\_11/index.htm](http://www.acq.osd.mil/ncbdp/nm/nm_book_5_11/index.htm)
- TM 5-690 - Grounding & Bonding in C4ISR Facilities  
[http://www.wbdg.org/ccb/ARMYCOE/COETM/tm\\_5\\_690.pdf](http://www.wbdg.org/ccb/ARMYCOE/COETM/tm_5_690.pdf)
- EMP Lightning Threats to Telecom 1978  
<http://www.dtic.mil/dtic/tr/fulltext/u2/a060629.pdf>
- AF Manual for Design & Analysis of Hardened Structures 1974  
<http://www.dtic.mil/docs/citations/ADA955183>
- See the following in Wikipedia
  - Geomagnetically induced current
  - Electromagnetic Pulse
  - Nuclear electromagnetic pulse
  - Faraday cage
  - Effects of nuclear weapons
- If you want to protect everything, go to link below, click book image “EMP Protect Family, Homes and Community” by Don White and Jerry Emanuelson  
[www.futurescience.com/emp/EMP-Sitemap.html](http://www.futurescience.com/emp/EMP-Sitemap.html)

### Testing for Connectivity

1. Test for Resistance  $\Omega$
2. Set for lower readings (< 2000  $\Omega$ )
3. Touch probes together, note reading (0-2)
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- Note – some *multimeters* have *beeper*

