EMP?

What, Me Worry?

What Is EMP You Ask?

- EMP stands for ElectroMagnetic Pulse
- EMP is NOT Lightning, although the two share some characteristics
- EMP is a large, impulse type of electromagnetic wave
- Depending on how it is generated, there can be different types or ‘flavors’ of EMP and each requires different mitigation strategies

How Can EMP Get Generated?

- Most people who know it exists think it is generated only by nuclear weapons.

Nuclear EMP (NEMP)

- High Altitude EMP (HEMP) would be caused by a nuclear explosion above 30 miles in altitude.
- Created by impact of high-energy gamma radiation from the blast with molecules of atmosphere (O2 and N2) creating Compton electrons

System-Generated EMP (SGEMP)

- Produced by interaction of high energy gamma radiation with equipment as opposed to the atmosphere
- Think satellites and airplanes at altitude

Magneto-Hydrodynamic EMP(MHD-EMP)

- Occurs later, has smaller amplitude and longer duration
- Poses the greatest threat to long land lines such as telephone, power and cable tv lines

- Even could affect submarine cables!

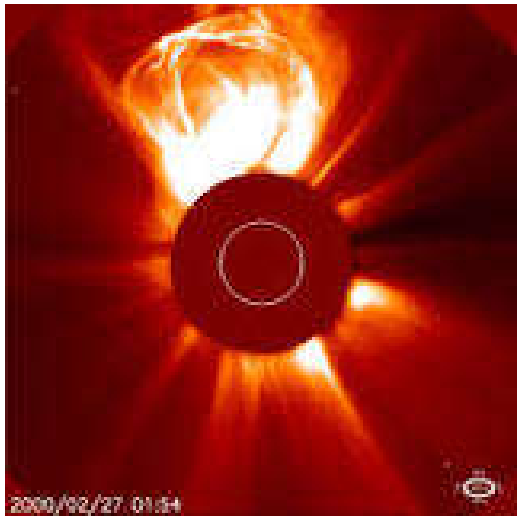
But Nuclear Explosions Are Not the Only Sources of EMP

- Let's get the terrorist stuff out of the way first. There are now conventional explosive-driven EMP bombs. They could be made in your garage if you knew what you were doing.
- Would only have very localized effects because they generate EMP in a different way and have to be delivered close to the ground.
- Could cause havoc in a major city for limited amount of time.

Space Weather !?!

Coronal Mass Ejections (CME)

- A **coronal mass ejection** (or CME) is a giant cloud of solar plasma drenched with magnetic field lines that are blown away from the Sun during strong, long-duration solar flares and filament eruptions.
- Solar Energetic Particle events
- Geomagnetic Storms



CME's Won't Just Lead to Good DX

Enormous outbursts of energy from the Sun during late October and early November 2003 produced intense solar energetic particle events and triggered severe geomagnetic storms, the wide ranging effects of which were described as follows:

- "The Sydkraft utility group in Sweden reported that strong geomagnetically induced currents (GIC) over Northern Europe caused transformer problems and even a system failure and subsequent blackout.
- Radiation storm levels were high enough to prompt NASA officials to issue a flight directive to the ISS astronauts to take precautionary shelter.
  Airlines took unprecedented actions in their high latitude routes to avoid the high radiation levels and communication blackout areas. Rerouted flights cost airlines $10,000 to $100,000 per flight.
- Numerous anomalies were reported by deep space missions and by satellites at all orbits. GSFC Space Science Mission Operations Team indicated that approximately 59% of the Earth and Space science missions were impacted.
- The storms are suspected to have caused the loss of the $640 million ADEOS-2 spacecraft. On board the ADEOS-2 was the $150 million NASA SeaWinds instrument.
- Due to the variety and intensity of this solar activity outbreak, most industries vulnerable to space weather experienced some degree of impact to their operations."

The Carrington Event

- The **solar storm of 1859**, also known as the **Carrington event**, was a powerful geomagnetic solar storm in 1859 during solar cycle 10.
- A solar coronal mass ejection hit Earth's magnetosphere and induced one of the largest geomagnetic storms on record.
- The associated "white light flare" in the solar photosphere was observed and recorded by English astronomers Richard C. Carrington and Richard Hodgson

The Carrington Event Effects

- Aurorae were seen around the world, those in the northern hemisphere as far south as the Caribbean; those over the Rocky Mountains in the US were so bright that their glow awoke gold miners, who began preparing breakfast because they thought it was morning.
- People in the northeastern US could read a newspaper by the aurora's light. The aurora was visible as far from the poles as Sub-Saharan Africa (Senegal, Mauritania, perhaps Monrovia, Liberia), Monterrey and Tampico in Mexico, Queensland, Cuba and Hawaii.
- Telegraph systems all over Europe and North America failed, in some cases giving telegraph operators electric shocks. Telegraph pylons threw sparks. Some telegraph operators could continue to send and receive messages despite having disconnected their power supplies.
- This was 1859, we are talking about really robust equipment here

Oh Yeah, Lightning

- **Lightning** is a sudden electrostatic discharge during an electrical storm between electrically charged regions of a cloud (called intra-cloud **lightning** or IC), between that cloud and another cloud (CC **lightning**), or between a cloud and the ground (CG **lightning**).
- Lightning is primarily a current event. Objects struck by lightning experience heat and magnetic forces of great magnitude.
- Lightning protection consists mainly of conducting the strike to ground.

OK, I've Got Lightning Protection, Now What?

- You Do Have Lightning Protection for those outside antennas, right?
- Well, you need a little bit more for EMP, although lightning protection is a good first step
- EMP events cover wide areas and affect all kinds of equipment in different ways than lightning.

First Things First

- Like in a lightning storm, DISCONNECT ANTENNAS if you know that EMP is likely (obviously mostly for space weather warnings)
- Disconnect all power supply cables from BOTH the rig and the power supply. That includes the AC cable. If possible, remove both ends! Don't leave the loose ends near the rig.
- Remember, if the EMP hits while you are disconnecting these things, particularly antennas, you could suffer damage, just like with lightning. Do it right away if you get warning.

Let Me Digress a Bit

- OK, Why is true EMP something we have to think about differently?
- It is wider-spread than the effects of lightning
- The energy of a HEMP is spread over a major portion of the **RF SPECTRUM**
- HEMP can have rise times of .001 to 100 seconds and peak voltages from 1 to **5 Megavolts**

SO?

- Think of Lightning as a current event
- Think of EMP as a voltage event
- Lightning you have to prevent current from causing damage by shunting it to the ground
- EMP you have to prevent voltage from reaching sensitive components
- CME’s and Solar Storms are the mixed martial arts of the EMP world

MOV’s and Spark Gaps

- You need protection that can react fast to transient voltages
- Metal Oxide Varistors (MOV’s)
- Gas Discharge Tube Spark Gaps (not just gaps)
- Zener Diodes (Avalanche Diodes)
- Thyristors
- Series Mode Surge Suppressors (Whole House)

If You Know It's Coming or Have Spares

- Create a Faraday Cage
- Skin Effect Becomes Your Friend
- Layered aluminum foil and insulators
- Anti-static bags
- Garbage cans (Metal Galvanized)
- Metal Ammo Cans (with bonding straps or sanding)
- Don't assume one method will work-redundancy isn't being stupid again and again.

The Well-Prepared Ham Shack

Electromagnetic Pulse and the Radio Amateur

Part 4: What can be done to protect an Amateur Radio station from lightning and EMP transients? Here are some ideas on procedures and protective devices.†

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The equipment test program described in the preceding three articles demonstrates that most Amateur Radio installations can be protected from lightning and EMP transients with a basic protection scheme. Most of the equipment is not susceptible to damage when all external cabling is removed. You can duplicate this stand-alone configuration simply by unplugging the ac power cord from the outlet, disconnecting the antenna feed line at the rear of the radio and isolating the radio gear from any other long metal conductors. Or, you can add two transient-protection devices to the interconnected system; that will also closely duplicate the stand-alone configuration.

The ac power line and antenna feed line are the two important points that should be outfitted with transient protection. This is the minimum basic protection scheme

†Parts 1-3 appear in Aug, Sep and Oct 1986 *QST*.

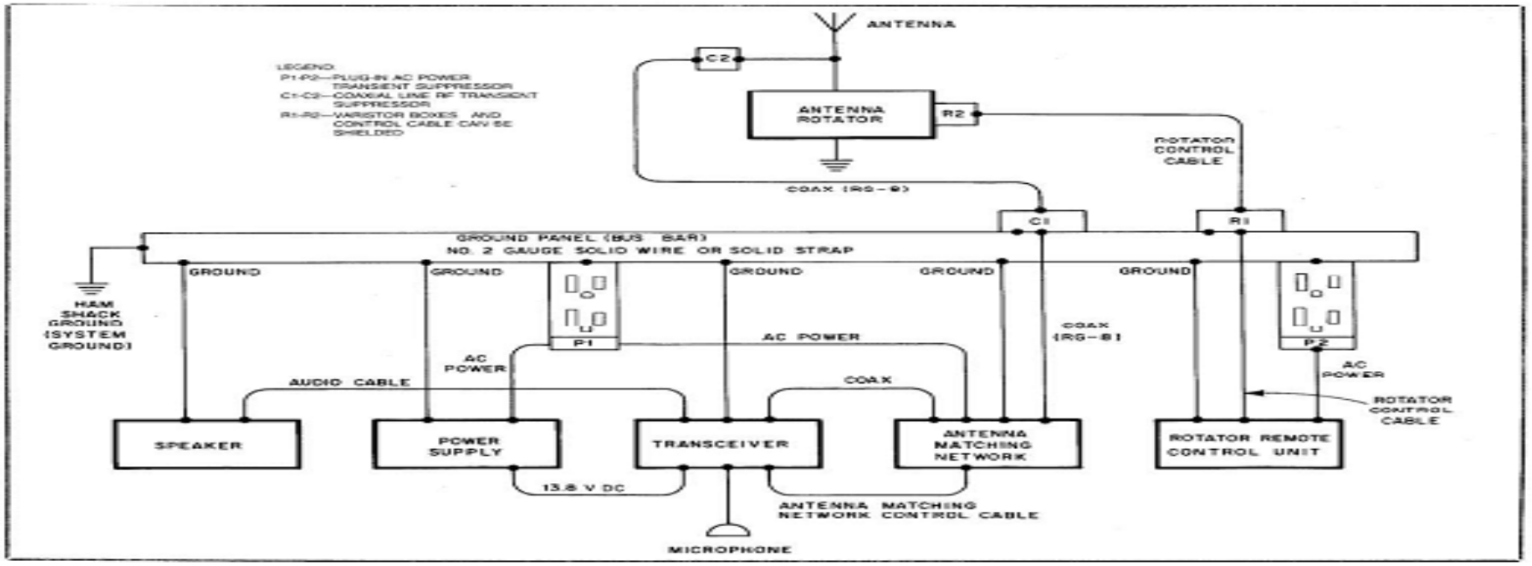

Fig 12—Transient suppression techniques applied to an Amateur Radio station.

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QUESTIONS?