

Lightning EMP (ElectroMagnetic Pulse)!

2011 July 12
Kai Siwiak, KE4PT

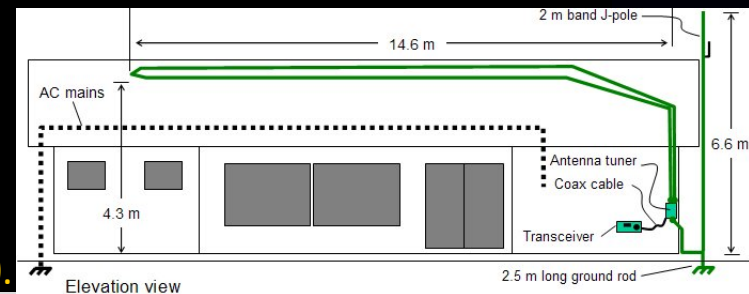
*A South Florida DX Association production prepared for
the Broward Amateur Radio Club*



“It was a dark and stormy night;
the rain fell in torrents* ...”

- Evening of May 14, 2011 lightning struck at KE4PT
- The station was well grounded and ‘protected’, but ...
- Lightning found a path to ‘touch’:
 - The ham transceiver
 - Wireless-LAN components
 - Air conditioner
 - Buried phone line
 - CATV service point

*Edward Bulwer-Lytton, in his novel *“Paul Clifford”*, 1830.



Florida is the Lightning Capital of the USA

- Lightning can have a profound effect on our ham radio activities
- Proper grounding helps protect our stations and our homes
- However, the direct conductive path is not lightning's only path to destruction
- Radiated electromagnetic pulse (EMP) from a lightning strike can also cause mayhem and damage in the most unlikely places
- Here, we will trace the effects of that possibility

A Median Lightning Bolt carries an Electric Current of 30,000 Amps

- The median bolt
 - transfers 15 coulombs of electric charge
 - transfers 500 mega joules of energy (equal to 120,000 food calories, or 1,000 bottles of beer)
- Large bolts of lightning can carry up to 120,000 Amps and 350 coulombs
- One bolt has an average of 4 strikes

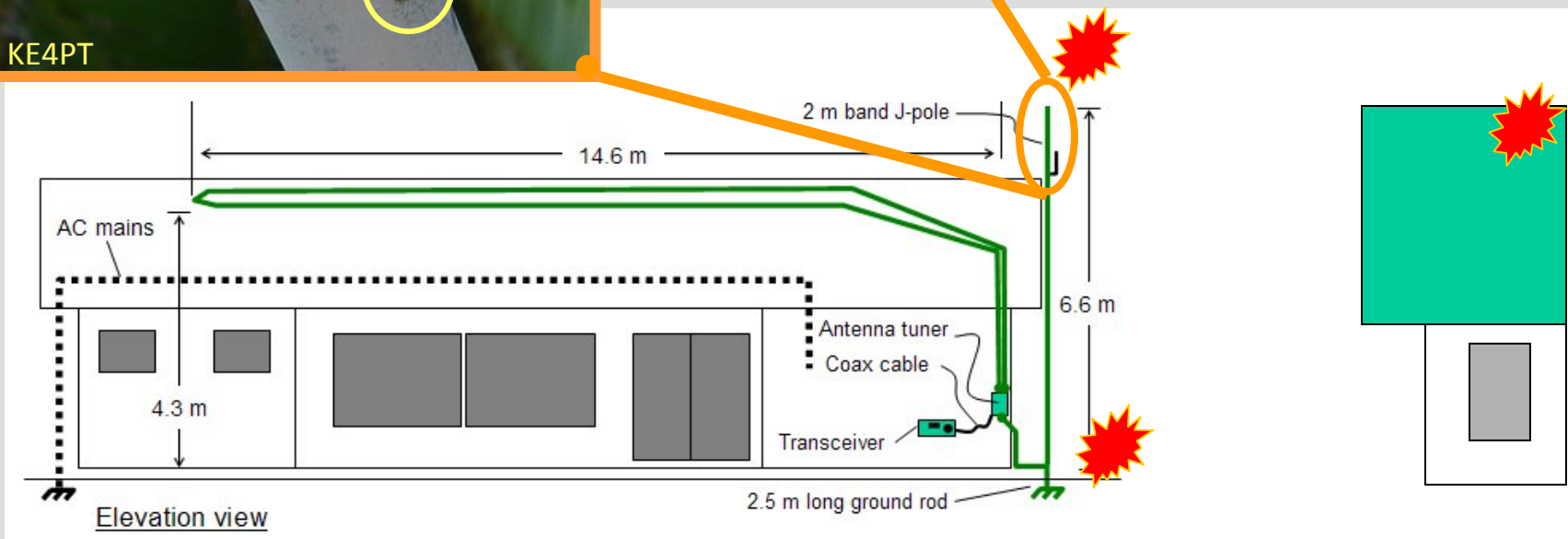
http://www.srh.noaa.gov/jetstream/lightning/lightning_safety.htm

The Bolt ...

- Struck a J-pole Antenna
- Struck the ground
- Struck neighbor's roof



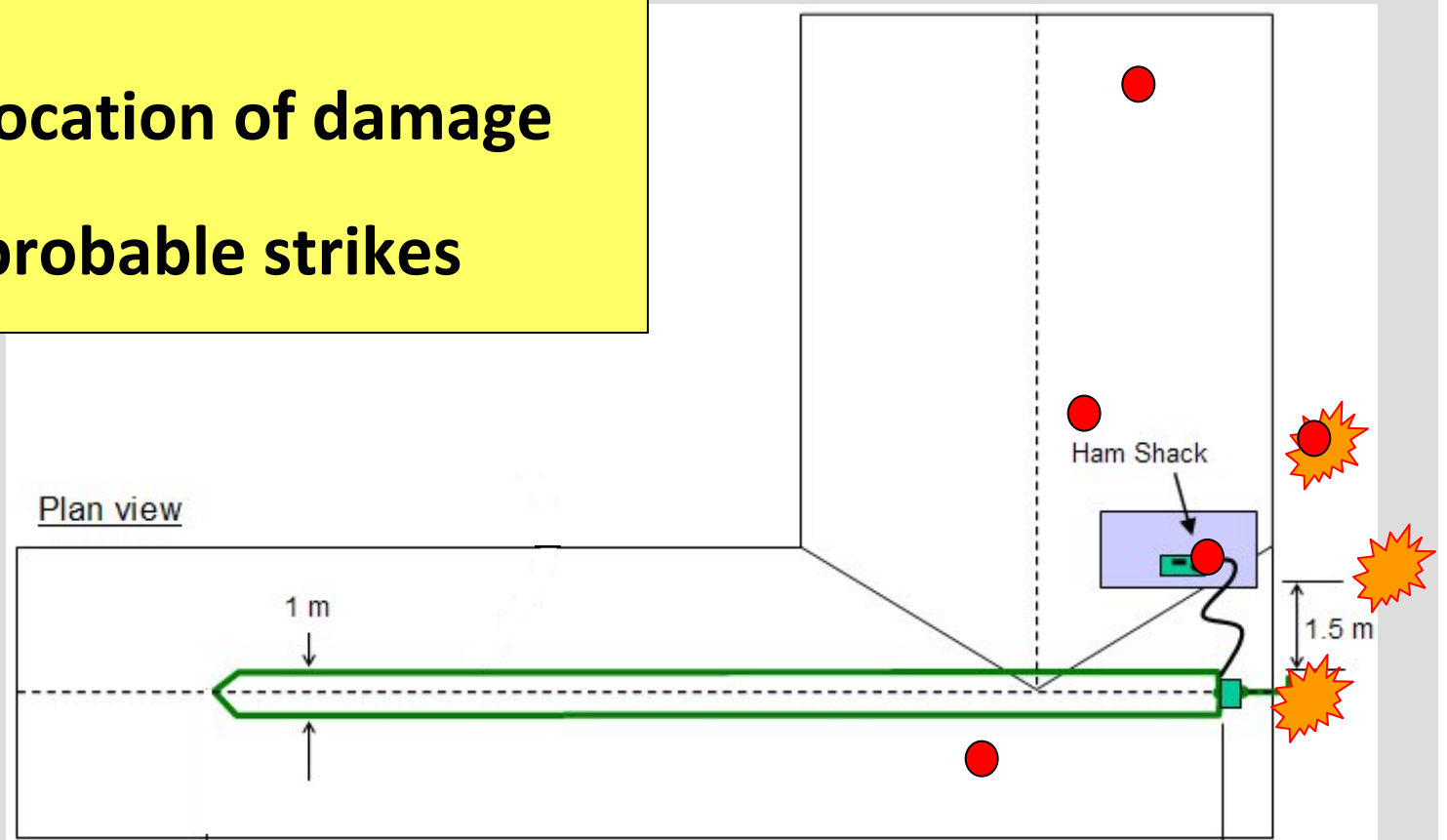
Photo: KE4PT



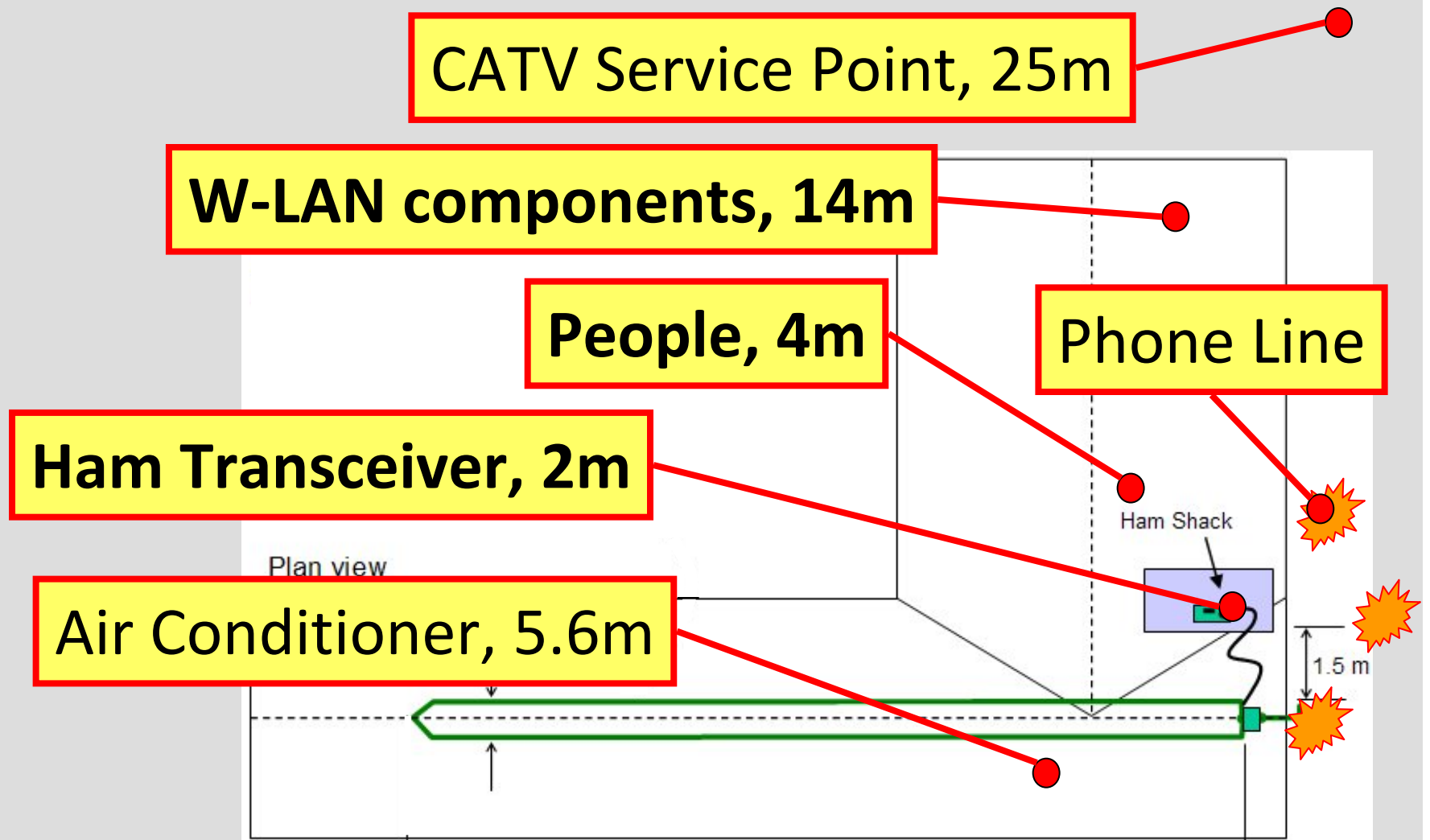
Touched by the Bolt

Top View of House

- location of damage
- ☀ probable strikes



Touched by the Bolt

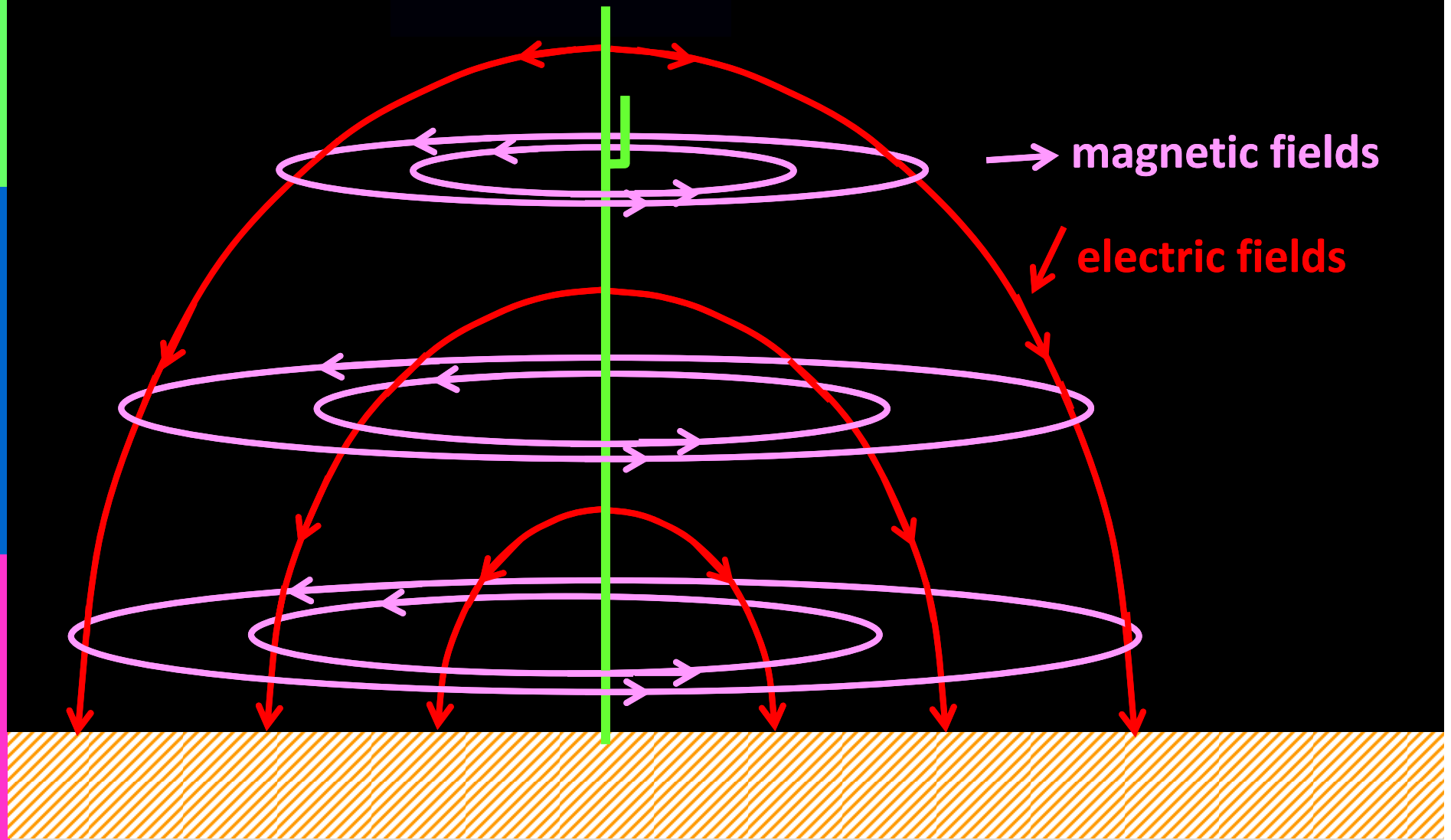


The Conductive Paths are Improbable!

- The W-LAN damage was not in any credible conductive path
- The Transceiver damage was not in any credible conductive path
- The perceived “tingle” from the strike was definitely not from a conductive path
- So ... what caused the mayhem ???

EMP:

anatomy of a sneaky path



→ magnetic fields

↘ electric fields

“New Study* Indicates Lightning Can Kill Without Leaving a Mark”

- “induced currents within the body could ... disrupt and fibrillate the heart, possibly causing death”
- “lightning striking near victims could have provided enough of a magnetic field to induce a brief, severe current causing death”
- “lightning kills in three ways: direct hit; indirect ‘side flash’ hit; or electrocution by ground currents”
- “Magnetic induction hypothesis now presents a fourth route for lightning injury or death”
- A 2007 study** corroborates these 1998 findings

*ScienceDaily: (June 30, 1998).

**Davide Pavanello, Electromagnetic Radiation from Lightning Return Strokes to Tall Structures, École Polytechnique Fédérale de Lausanne, Thèse No. 3713 (2007), 26 Jan 2007.

Not-So-New-Study (1985) Finds that ...

“the electrical forces surrounding the forked bolts ... may ... kill people”

– Ewen Thompson,
Professor of EE, UF

Lightning's electrical field may kill, researchers say

GAINESVILLE — (UPI) — An invisible component of lightning may be responsible for many of the nation's 2,500 lightning-related deaths in the past 25 years, researchers say.

“When people think of damage from lightning, they think of direct strikes,” said Ewen Thomson, an electrical engineering professor at the University of Florida.

“But it's the electrical forces surrounding the forked bolts we see that are not visible to the eye that may blow up more television sets and kill people talking on the telephone.”

From 1959 through 1983, lightning claimed the lives of 2,500 people — a toll surpassed in the United States only by casualties from flash floods. Florida led the nation with 245 lightning-related deaths and 663 injuries, according to the National Weather Service.

Ironically, lightning claimed another victim in Florida on Monday.

A 45-year-old man was struck by lightning and killed when a storm came up as he and four other men were doing maintenance work on a city water tower in Tampa. Police spokesman Johnny Barker said the man was not from Florida and his identity would be withheld pending notification of relatives.

“Each bolt of lightning is surrounded by an electrical field, similar to the magnetic field

illustrated in grade school science demonstrations done with metal filings and a magnet on a sheet of paper,” Thomson explained.

Traditionally, Thomson said, the vertical component [the forked streak] has been measured to determine things such as the intensity of the bolt. But the smaller and invisible horizontal feature of the bolt has been virtually ignored.

Thomson and Martin Uman, director of the UF laboratory handling the research, use a globe-like device — isolated from the ground by an insulated tripod and hooked to a computer — to measure this horizontal component.

“The major reason we want to get a handle on the horizontal component is that it contributes significantly to the voltage overloads on overhead power lines, underground cables and any other horizontal line that carries electrical current or signal,” Thomson said. “This includes telephone and power transmission lines that go into the houses.”

Thomson said he hopes his research will “provide the power and telephone companies with information and parameters that will let them predict what sort of lightning induces voltages they'll get in specific areas so they can design their power lines accordingly.”

9 July 85 Miami Herald

“ If you feel your hair stand on end,
lightning is about to strike”

There may be little or nothing you can do to keep from being struck by lightning. As a last desperate resort:

- ▶ **Crouch down on the balls of your feet, put your hands over your ears, and bend head down.**
- ▶ **Make yourself as small a target as possible, and minimize your contact with the ground.**
- ▶ **Do not lie flat on the ground.**



**Coaches & Sports
Officials Guide to**

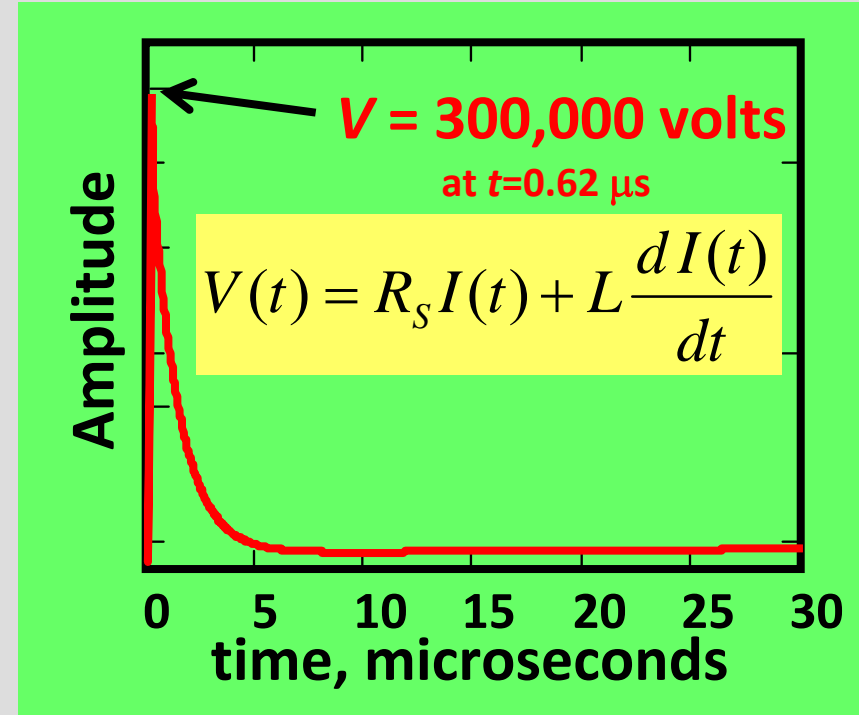
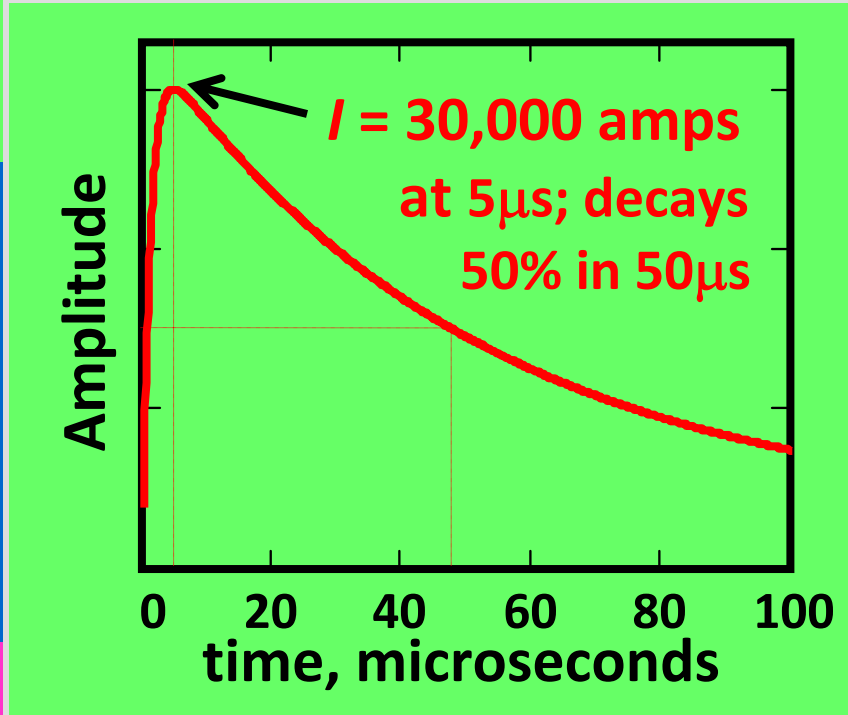
**Lightning
Safety**

[http://www.lightningsafety.noaa.gov/
resources/CoachGuide.pdf](http://www.lightningsafety.noaa.gov/resources/CoachGuide.pdf)

We Speculate ...

- We don't really know how the strength of the lightning bolt
- For an analysis, we use the ***Median*** bolt (50% are stronger, 50% are weaker)
- Assume a peak current is 30,000 Amps
- Rise time is 5 μs , decays in 50 μs to half that value

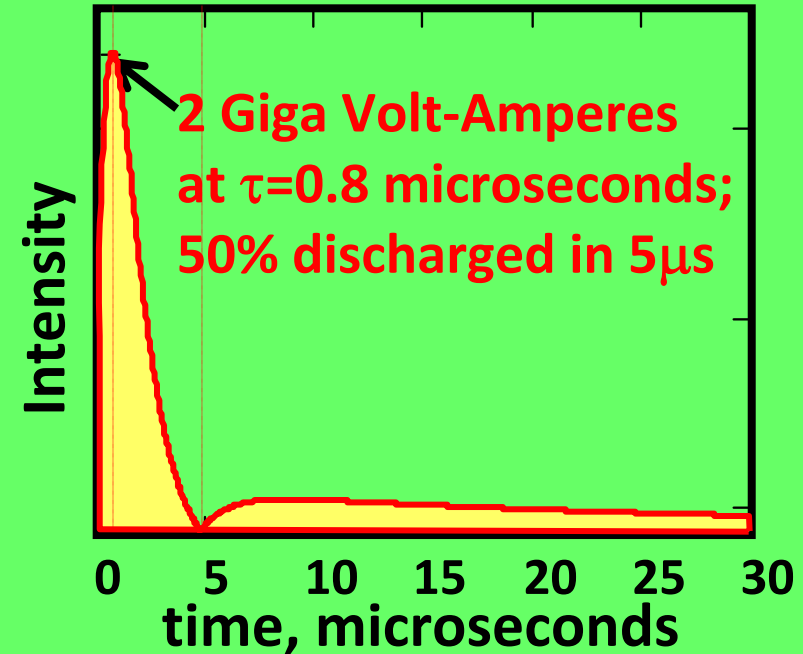
Anatomy of a *Median* Lightning Bolt



- Martin A. Uman, *Lightning*, Dover: 1984.
- David Bodle, *Electrical Protection Guide for Land Based Radio Facilities*, Joslyn Electronic Systems, 1971.
- Davide Pavanello, *Electromagnetic Radiation from Lightning Return Strokes to Tall Structures*, École Polytechnique Fédérale de Lausanne, Thèse No. 3713 (2007), 26 Jan 2007.

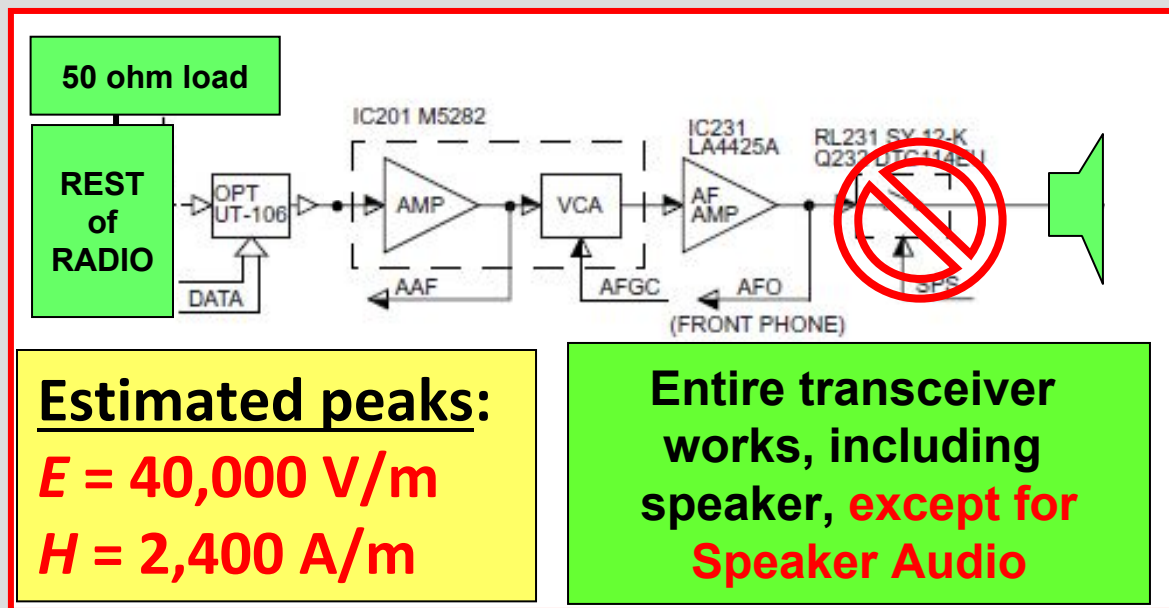
Model of the Lightning Pulse

- Reactive power at the mast can have enormous peaks
- Results in reactive (and radiated) fields
- Fields die off rapidly with time and distance



Touched by the Ghost of a Bolt?

Ham Transceiver, 2m away

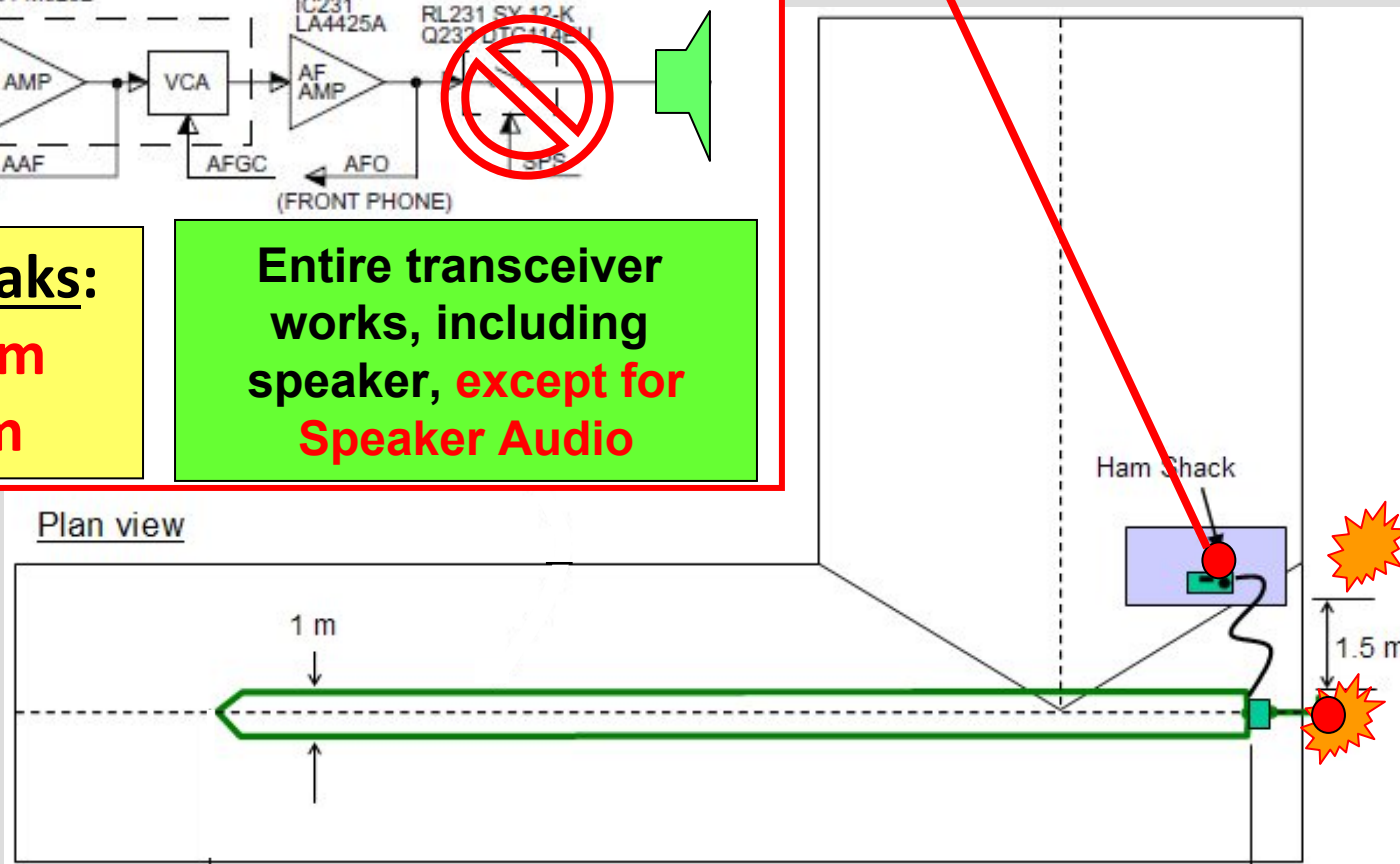


Estimated peaks:

$$E = 40,000 \text{ V/m}$$

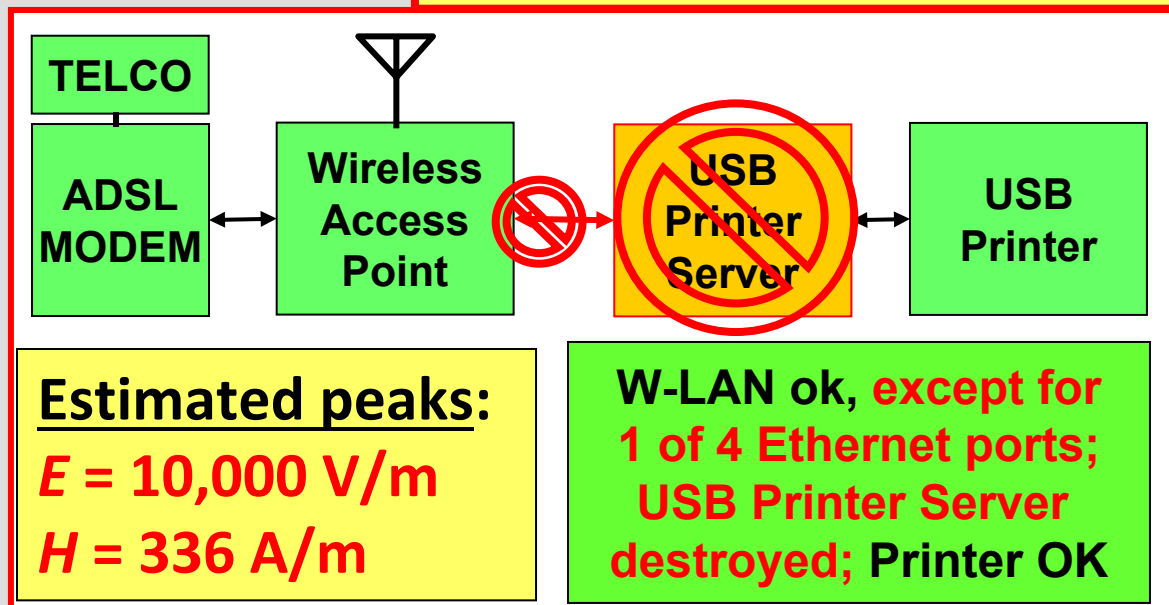
$$H = 2,400 \text{ A/m}$$

Entire transceiver works, including speaker, except for Speaker Audio



Touched by the Ghost of a Bolt?

W-LAN components, 14m



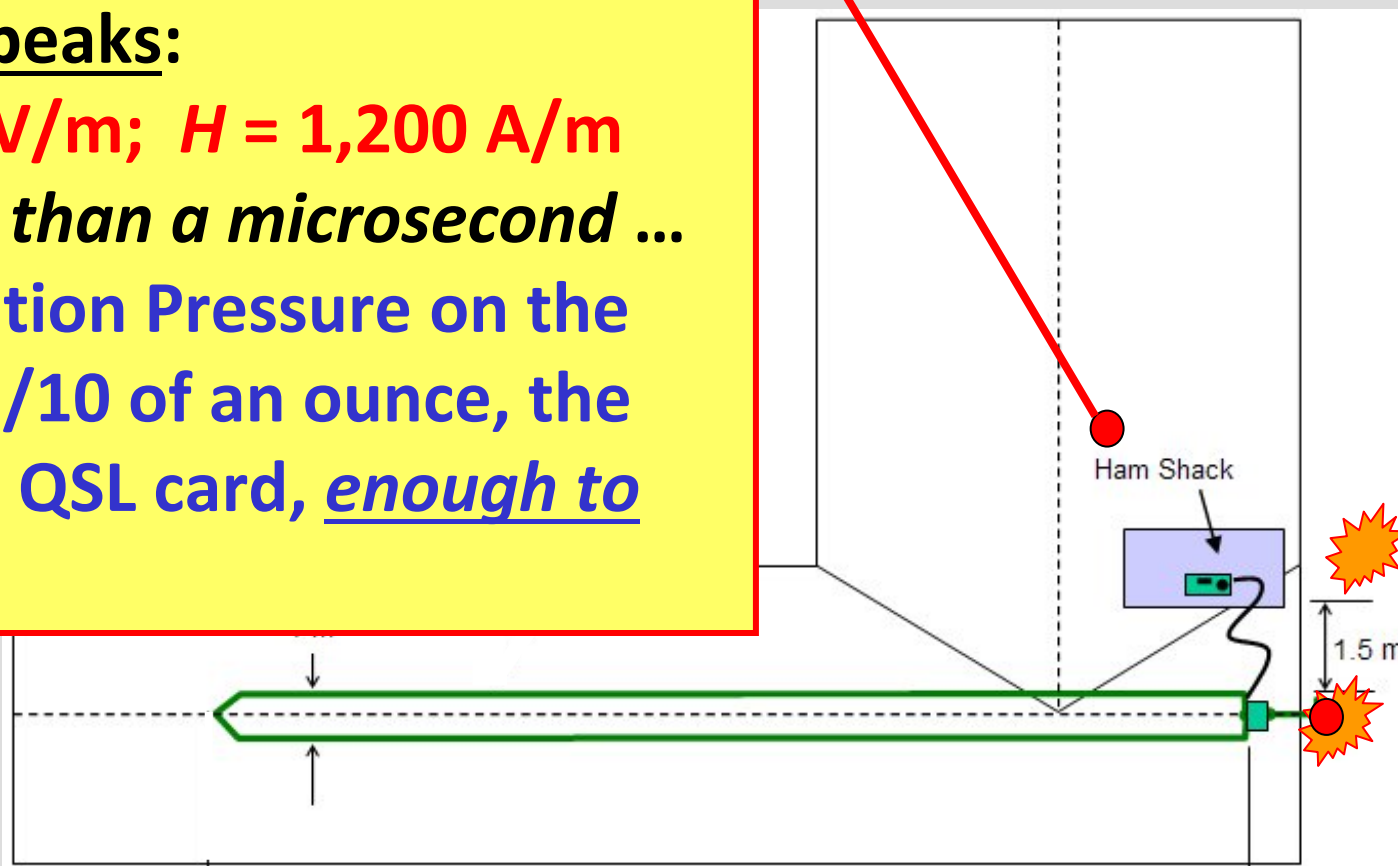
Touched by the Ghost of a Bolt?

People, 4m away

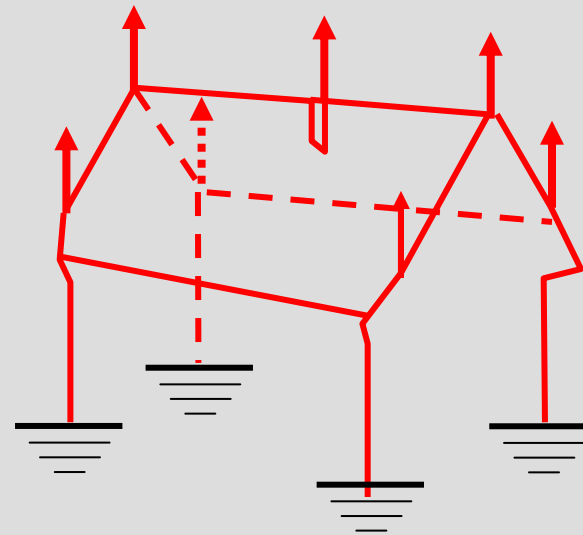
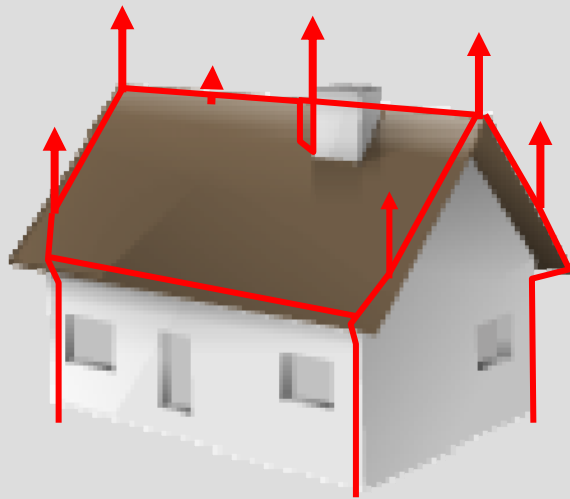
Estimated peaks:

$E = 31,000 \text{ V/m}$; $H = 1,200 \text{ A/m}$
for less than a microsecond ...

Total Radiation Pressure on the body was 1/10 of an ounce, the weight of a QSL card, enough to perceive!



How to Protect the Home Against Lightning *and* EMP?



Make a Faraday Cage!

An Actual Installation



Bulky Ground Rods and Cables



29 strands of 17 gauge copper wire layered in a basket weave cable, O.D. = ~3/8 in



Photos: Tom Manning

Summary

- Lightning ***will*** find a way
- The conductive path is not the only path to destruction
- Lightning EMP can be dangerous, destructive and deadly

The KE4PT Rules of Ham Radio:

- (1) Please be courteous
- (2) **Don't operate in an electrical storm**
- (3) If you ignore rule (1) please also ignore rule (2).





500kV_Switch.mpg

500 kV Switch Experiment



2011 July 12

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