PLASMA ANTENNAS AS OFFENSE AND DEFENSE AGAINST WIRELESS CYBER ATTACKS, EMP,DEW, AND ELECTRONIC WARFARE IN GENERAL

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March 2013

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Bottom Line: Plasma Antennas can give protection against Wireless Cyber Attack, DEW, EMP, and Electronic Warfare

- When plasma antennas are turned off, all frequencies pass through them.
  - During a cyber wireless attack, infected wireless signals at all frequencies pass through the plasma antennas and do not infect the electronics attached to the plasma antenna
- When plasma antennas are lowered in plasma density, high frequencies pass through them and the lower frequencies can be received, reflected, or transmitted. The plasma antenna can operate at lower frequencies and be transparent to wireless cyber attacks at higher frequencies.
  - During a cyber wireless attack communications can take place at lower frequencies and not be effected by infected wireless signals at higher frequencies.
- Haleakala R&D can develop a plasma antenna that can detect a cyber attack from plasma density and pressure fluctuations which are programmed.
  - then the plasma antennas can be programmed to turn off or go into any of the modes discussed in this document to give protection against a wireless cyber attack.
- Plasma antennas have protection against Wireless Cyber Attack, DEW, EMP, and Electronic Warfare

Protection Against Wireless Cyber Attack using Plasma Antennas

- Plasma antennas are not infected by wireless cyber attacks at all frequencies when turned off.
- Plasma antennas are transparent at higher frequencies when the plasma density is lowered.
- Our plasma smart antenna can be protected against wireless cyber attacks with the external plasma shield.
- Plasma reconfigurable frequency selective surfaces in a radome protect antennas from wireless cyber attacks.
- Haleakala R&D can develop a plasma antenna that can detect a cyber attack from plasma density and pressure fluctuations which are programmed.
  - then the plasma antennas can be programmed to turn off or go into any of the modes discussed in this document to give protection against a wireless cyber attack.

Physics of Transmission and Reflection from a Plasma

The Concept of Cut-off and Filtering using Plasma Antennas

- The plasma frequency is proportional to the density of unbound electrons in the plasma or the amount of ionization in the plasma. The plasma frequency sometimes referred to a cutoff frequency is defined as:

$$\omega_p = \sqrt{\frac{4\pi n_e e^2}{me}}$$

where n_e is the density of unbound electrons, e is the charge on the

electron, and me is the mass of an electron

- If the incident EM frequency on the plasma is greater than the plasma frequency

$$\omega > \omega_p$$

the EM radiation passes through the plasma and the plasma is transparent.

Physics of Transmission and Reflection from a Plasma

The Concept of Cut-off and Filtering using Plasma Antennas

When

$$\omega < \omega_p$$

the plasma acts as a metal, and transmits and receives microwave radiation.

Note, the incident frequency in the next slide is given as:

$$\nu = \omega / 2\pi$$

Reconfigurable Communications Notch in a Plasma Antenna to Filter Out Infected RF Signals While Maintaining Communications During a Wireless Cyber Attack

- We can surround our plasma antenna by a ring of plasma tubes that act as a reflector.
  - If the plasma frequency in this ring is lower than that of the received signal, the signal passes on to the plasma antenna.
  - However, only those frequencies that are lower than the plasma frequency in the plasma antenna will be received.
  - All higher frequencies pass through both the ring of plasma tubes and the plasma antenna without interacting.
  - Mathematically, we can state that

$$\upsilon_{p_{ring}} \prec \upsilon_{signal} \prec \upsilon_{p_{antenna}}$$

  - where the received signal is between the plasma frequency of the ring and the plasma frequency of the enclosed antenna.
  - Since both the plasma frequency of the ring and the plasma frequency of the antenna can be reconfigured in milliseconds, the receiving notch can be moved about as desired

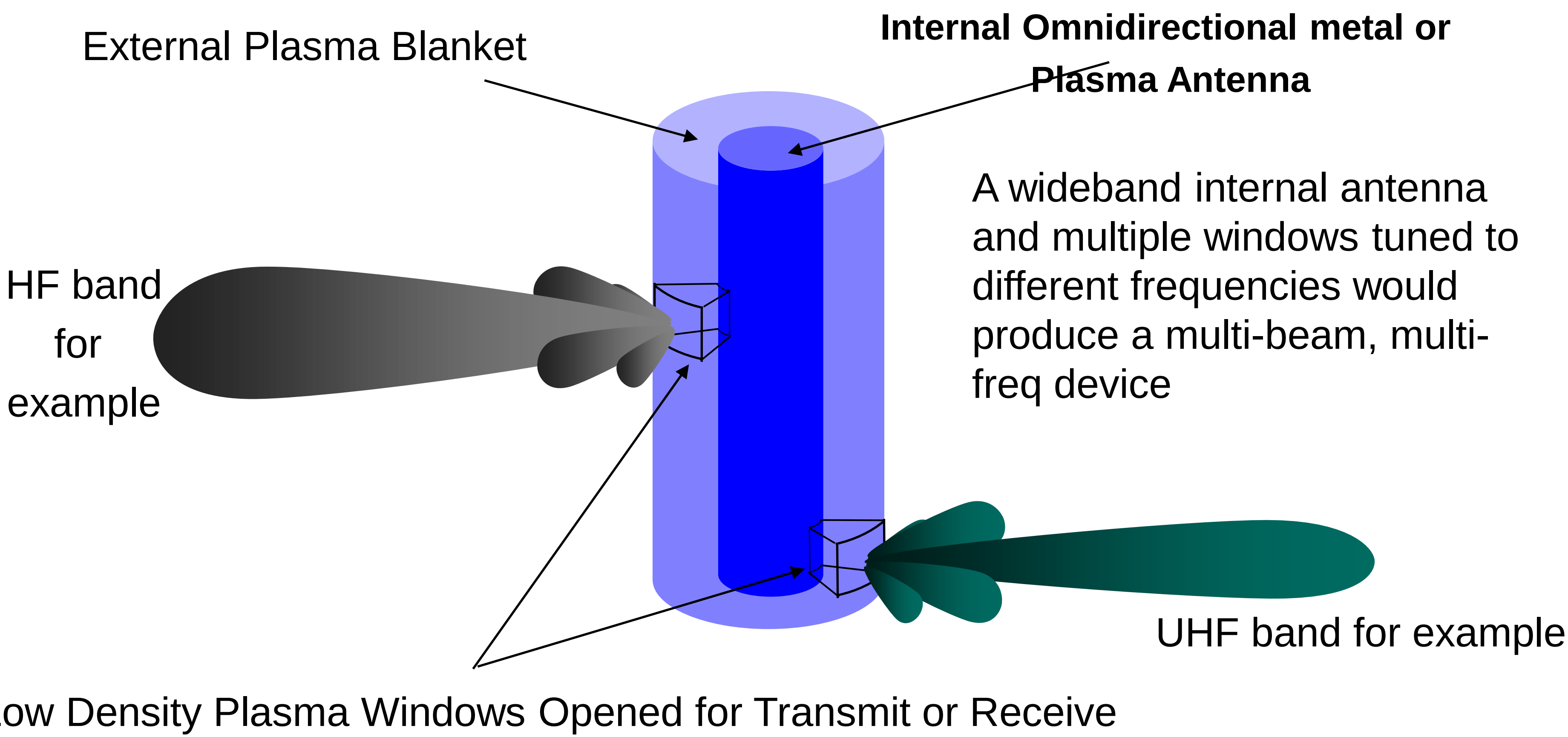
Smart Plasma Antenna

(Plasma Protects Inside Antenna Against Wireless Cyber Attack, DEW, EMP, and Electronic Warfare)

- Bottom line:
  - External plasma creates open plasma windows to enable receiving and transmitting.
  - Closed plasma windows protect inside antenna against wireless cyber attacks, jamming, and electronic warfare.
  - External plasma gives built in protection of the inside antenna against wireless cyber attacks, DEW, jamming, and electronic warfare.
    - The more intense the DEW, the more dense the plasma and the more protective it is.
    - The plasma uses the energy of the DEW to protect the inside antenna from DEW, jamming, and electronic warfare.

Tactical Capabilities Plasma Windowing Concept

(Plasma Protects Inside Antenna Against Wireless Cyber Attacks, EMP, DEW, and Electronic Warfare in General)



A wideband internal antenna and multiple windows tuned to different frequencies would produce a multi-beam, multi-freq device

Our Commercial Prototype
with Our Prototype Engineer Jeff Peck
(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)

Features of our Commercial Prototype

(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)

- **It currently weights about 10 pounds.**
  - **Some weight (but not much) will be added when we make the base rugged and surround the tubes with SynFoam to protect the tubes.**
  - **Future iterations of the prototype can be made smaller.**
  - **But nevertheless it is much smaller and lighter than large phased array antennas, and the performance is in many ways better.**
  - **Even in the prototype stage, our prototype is relatively inexpensive for a steerable smart antenna. Manufacturing would significantly reduce the price.**
- **It can steer the antenna beam 360 degrees in milliseconds.**
  - **Our future prototypes will steer in microseconds using Fabry-Perot-Etalon Effects.**

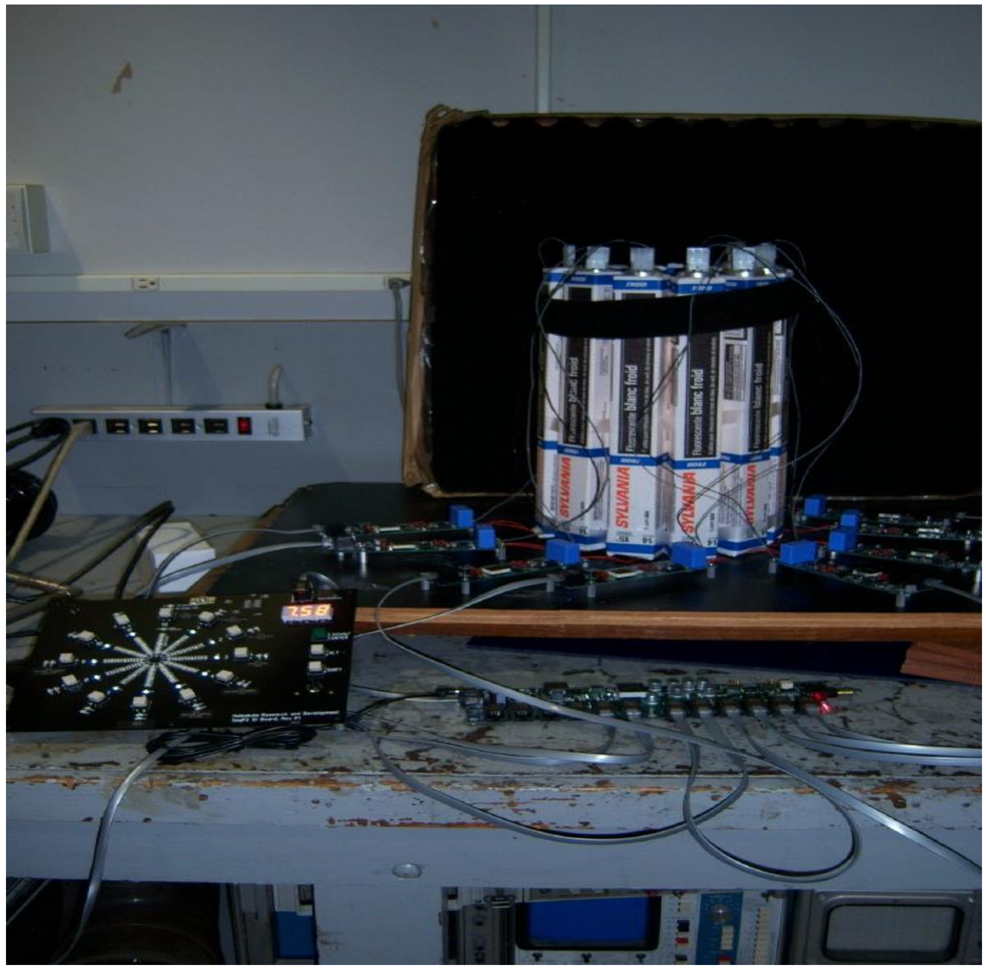
Features of our Commercial Prototype

(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)

- **It is intelligent and smart.**
  - **It can find and lock on to a transmitter.**
  - **In addition, one plasma window can lock on to a transmitter and a second plasma window can find a second transmitter.**
  - **It can reconfigure from single lobe, to multilobe, to no lobe configurations.**
- **It can run on a 12 volt car battery.**
- **It can be mounted on a tank, a humvee, a surface ship, a sub, etc. conveniently.**
  - **Other applications: last mile, Wi-Fi, base stations, etc.**
- **This commercial prototype will be packaged and made rugged by encasing it in SynFoam .**
  - **SynFoam is a lightweight, heat resistant, and very strong material.**
  - **SynFoam has an index of refraction of nearly one, making it invisible to RF waves.**

Our Commercial Prototype

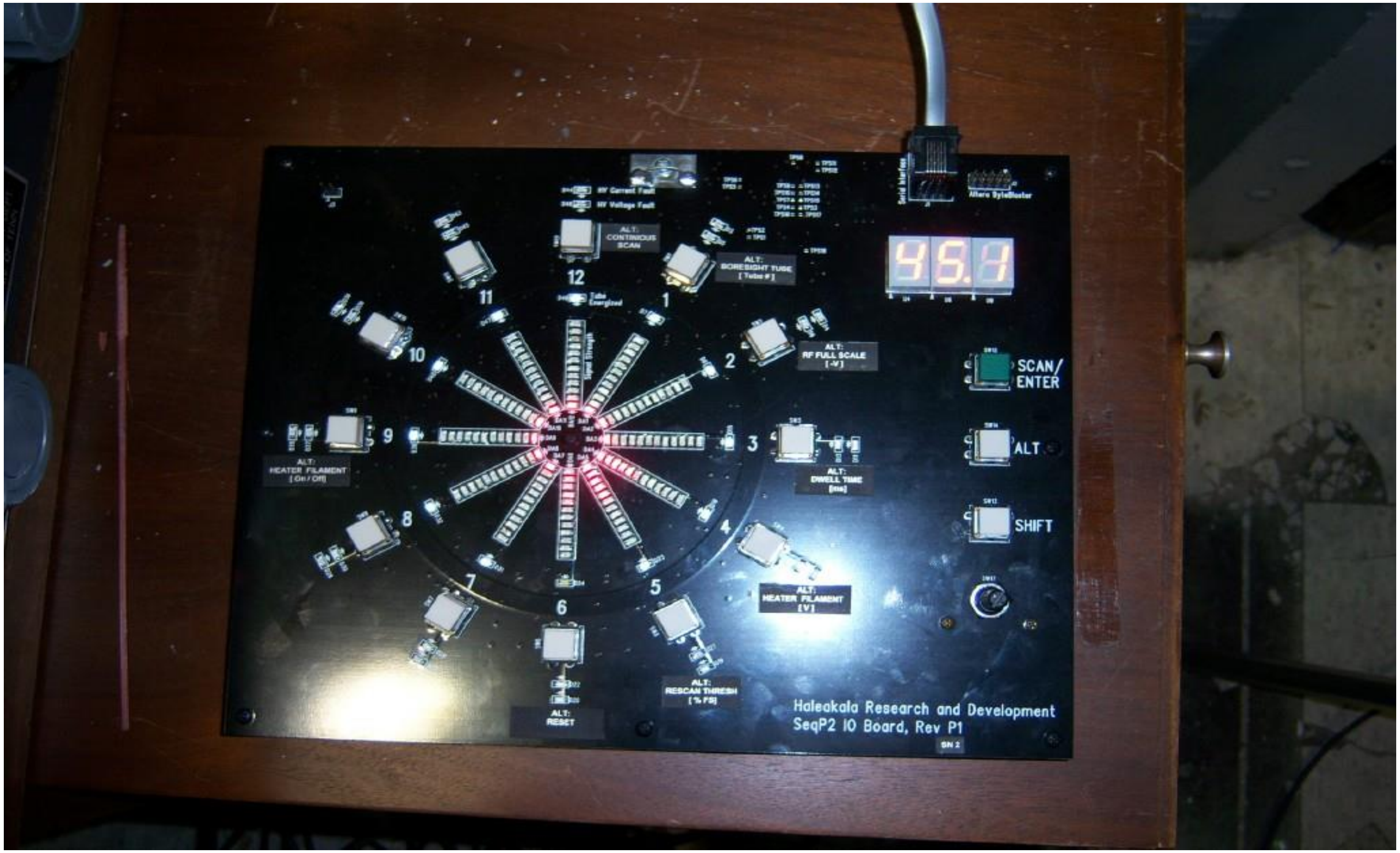
(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)



Our Commercial Prototype

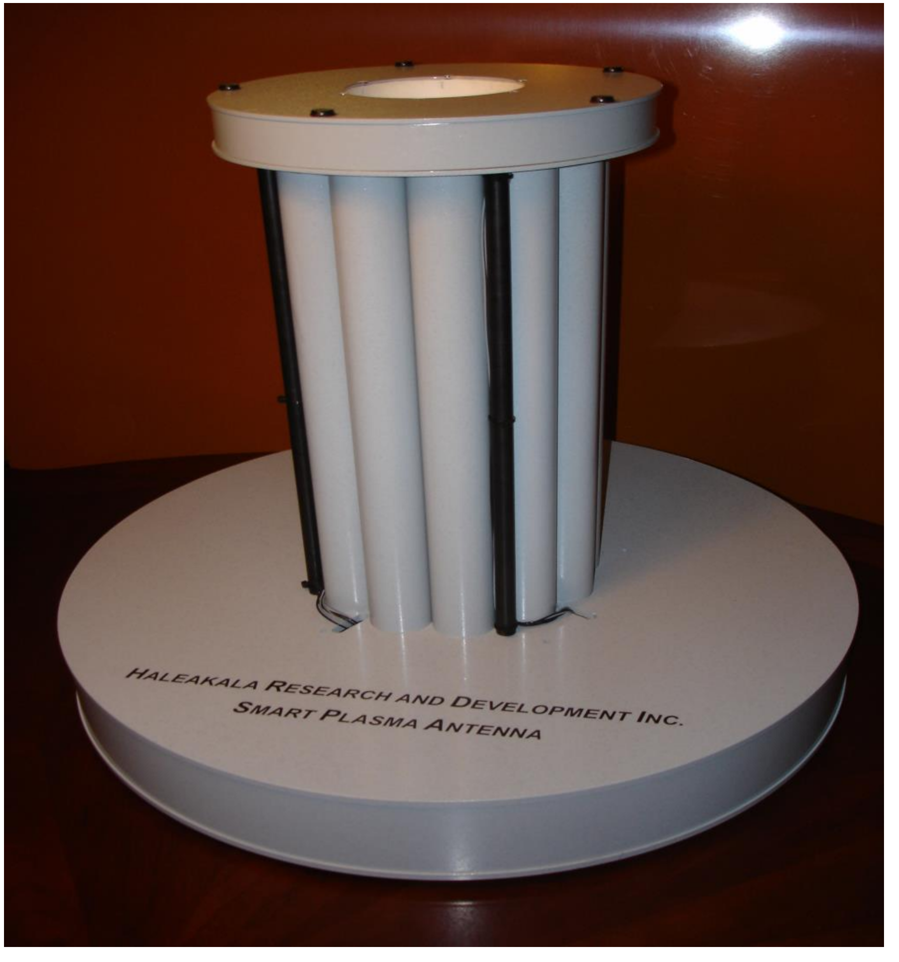
(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)

Open plasma window indicator. Orange color represents magnitude of power transmitted or received through an open plasma window.



Ruggedized Smart Plasma Antenna

(Plasma Protects Inside Antenna Against Wireless Cyber Attack, EMP, DEW, and Electronic Warfare in General)



CONCLUSIONS ON PLASMA ANTENNA PROTECTION AGAINST WIRELESS CYBER ATTACK, EMP, DEW, AND ELECTRONIC WARFARE IN GENERAL

- When plasma antennas are turned off, all frequencies pass through them.
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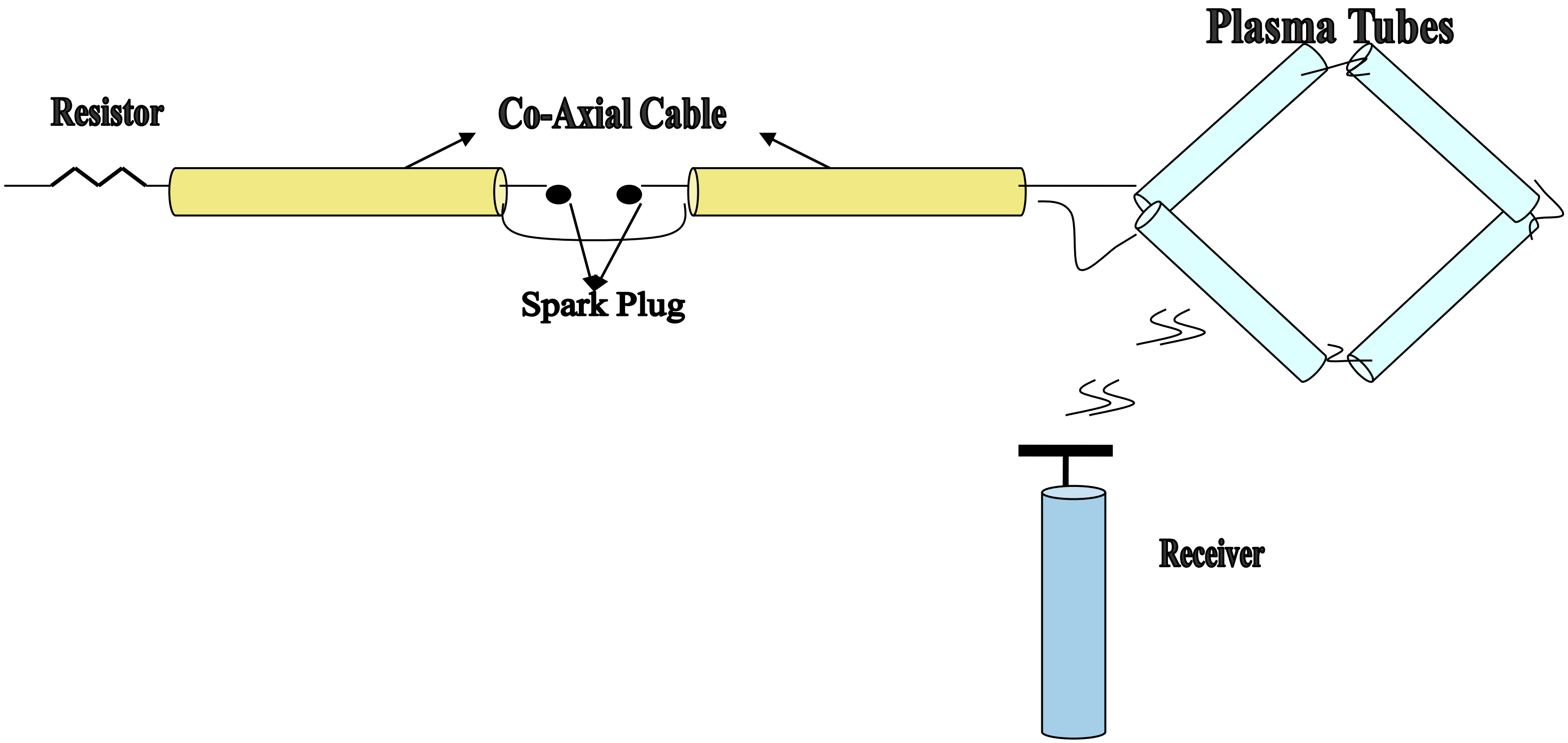
Plasma Antenna DEW Applications to Electronically Destroy Terrorist Weapons Non-lethally

This is important in civilian environments at home and abroad.

High Power Plasma Antenna

High Powered Plasma Antenna



High Powered Plasma Antennas

- We have tested a 2 megawatt pulsed power supply on a plasma antenna.
  - We found that in the transmitting mode, the plasma antenna was as efficient as a metal antenna for high power.
  - The plasma antenna has the added advantages of reconfigurability which a metal antenna does not have. This reconfirms what we found for lower powers.
- We have tested a megawatt power supply on a plasma antenna.
  - We used a pulsed power supply similar to the one used at the Naval Research Laboratory to generate megawatt radiation pulses with metal antennas. The design of the apparatus is shown in previous slide.
  - A section of 50 Ohm coaxial cable is charged to 25 Kilovolts. It then discharges through a spark gap into a second section of coaxial cable, then into four fluorescent lamps connected in series, forming a loop antenna.
  - Previous experiments have shown that if the pulse repetition rate is over a Kilohertz, the plasma in the fluorescent lamps is in essentially the steady-state The pulse of microwave radiation entering the plasma antenna radiates and is received on a small wire antenna about one meter away.

High Powered Plasma Antennas

- We then disconnected the wire antenna from the pulsed power supply, and connected it to a 10 Megahertz transmitter, and measured the received power on a panoramic receiver.
- We then connected the transmitter directly into the panoramic receiver, adjusted the signal strength to the previous value, and recorded the attenuation needed to do so. The attenuation required was 70 decibels.
- If we multiply the power received from the pulsed power supply via the plasma antenna by 70 decibels, we get the radiated power from the plasma antenna to be **5 Megawatts**! This result is in agreement with the measured radiation output from the Naval Research Laboratory, except that they used a metal antenna, and we used a plasma antenna

High Powered Plasma Antennas

- The received signal is about 5 Volts in amplitude. Since the input impedance of the antenna is 50 Ohms, as determined by terminating resistors, the received power is ½ Watt. The frequency of the radiation is about 13 Megahertz, in approximate agreement with the Naval Research Laboratory results with metal antennas.
- To calibrate the power output from the transmitter, we replaced the plasma antenna with a wire loop antenna of the same physical dimensions.
- We found that the received power from the pulsed power transmitter was the same as for the plasma antenna.

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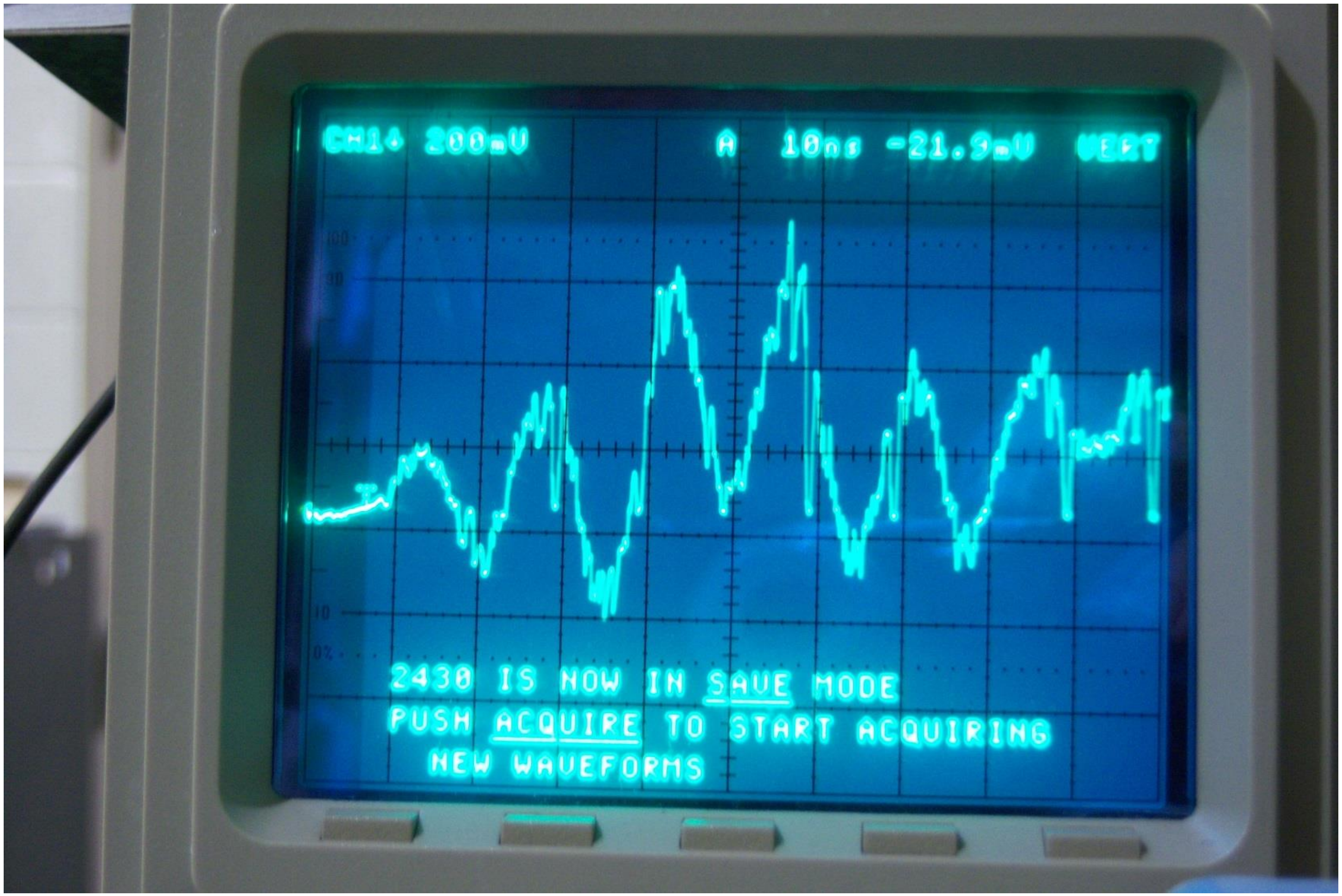
High Powered Plasma Antennas

- The power output from the pulsed plasma antenna is impressive. We used a hand-held fluorescent lamp illuminated by radiation from the pulsed power supply.
- The radiation does not ignite the fluorescent lamp-it must be pre-ignited.
- In addition, we attempted to calibrate the plasma antenna by coupling in radiation from a 10 Megahertz oscillator.
- The oscillator was immediately destroyed, a result that would be expected for electronic warfare!

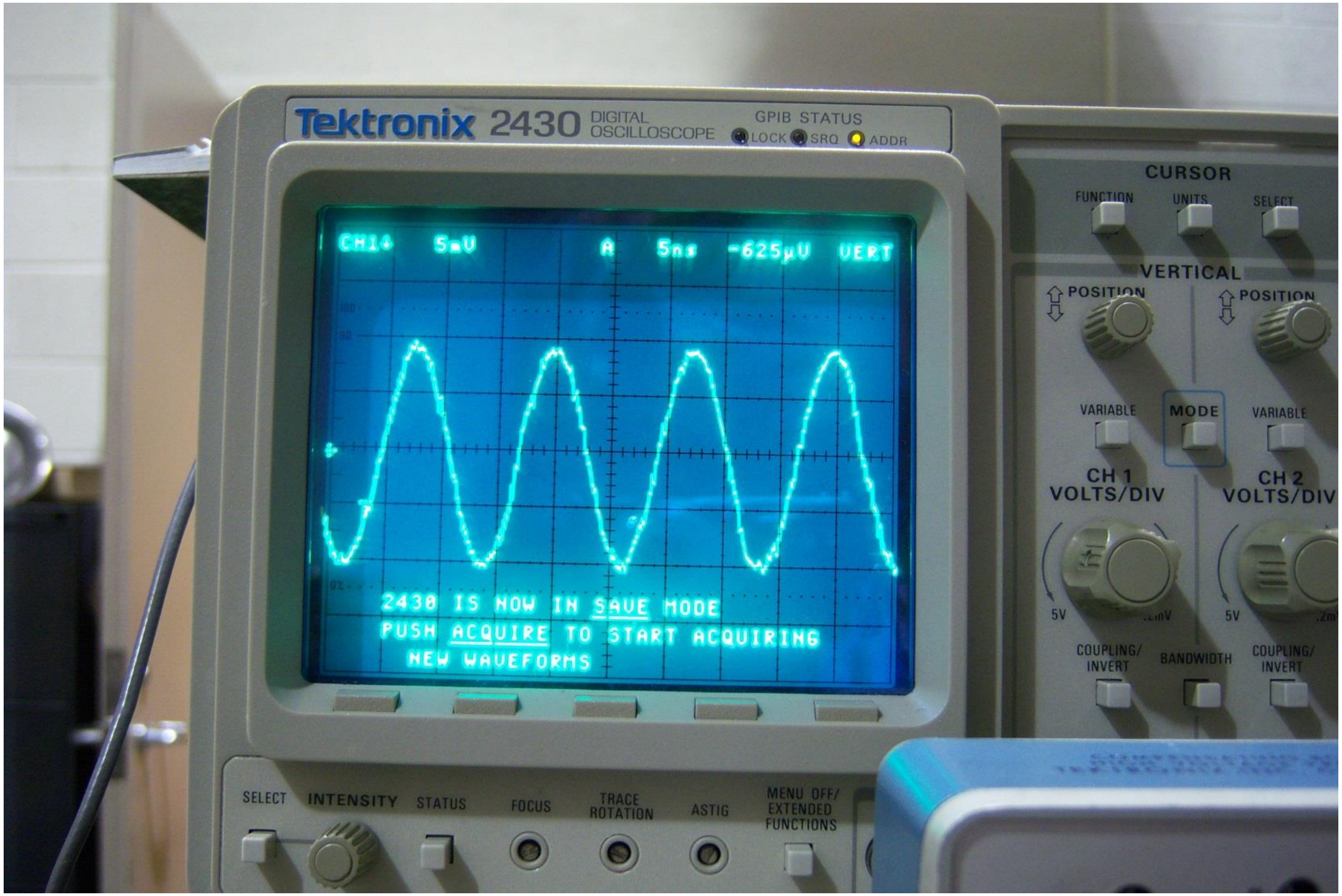
Megawatt Power Output

This is a repeat of one of the older slides showing the wavewform from our pulsed power system, but using the newer, digital oscilloscope. The time scale is shown on the screen.



Calibration Signal

This is a calibration slide using a local oscillator. It also uses the newer digital oscilloscope. The time scale is shown on the screen.



High Powered Plasma Antennas

Summary

• We have constructed and tested a plasma antenna operating at a power level of Megawatts. We found that in the transmitting mode, the plasma antenna was as efficient as a metal antenna for high power. The plasma antenna has the added advantages of reconfigurability which a metal antenna does not have. This reconfirms what we found for lower powers

• Plasma Antenna DEW Applications to Electronically Destroy Terrorist Weapons Non-lethally. This is important in civilian environments at home and abroad.