# PLASMA ANTENNA

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-8th Semester

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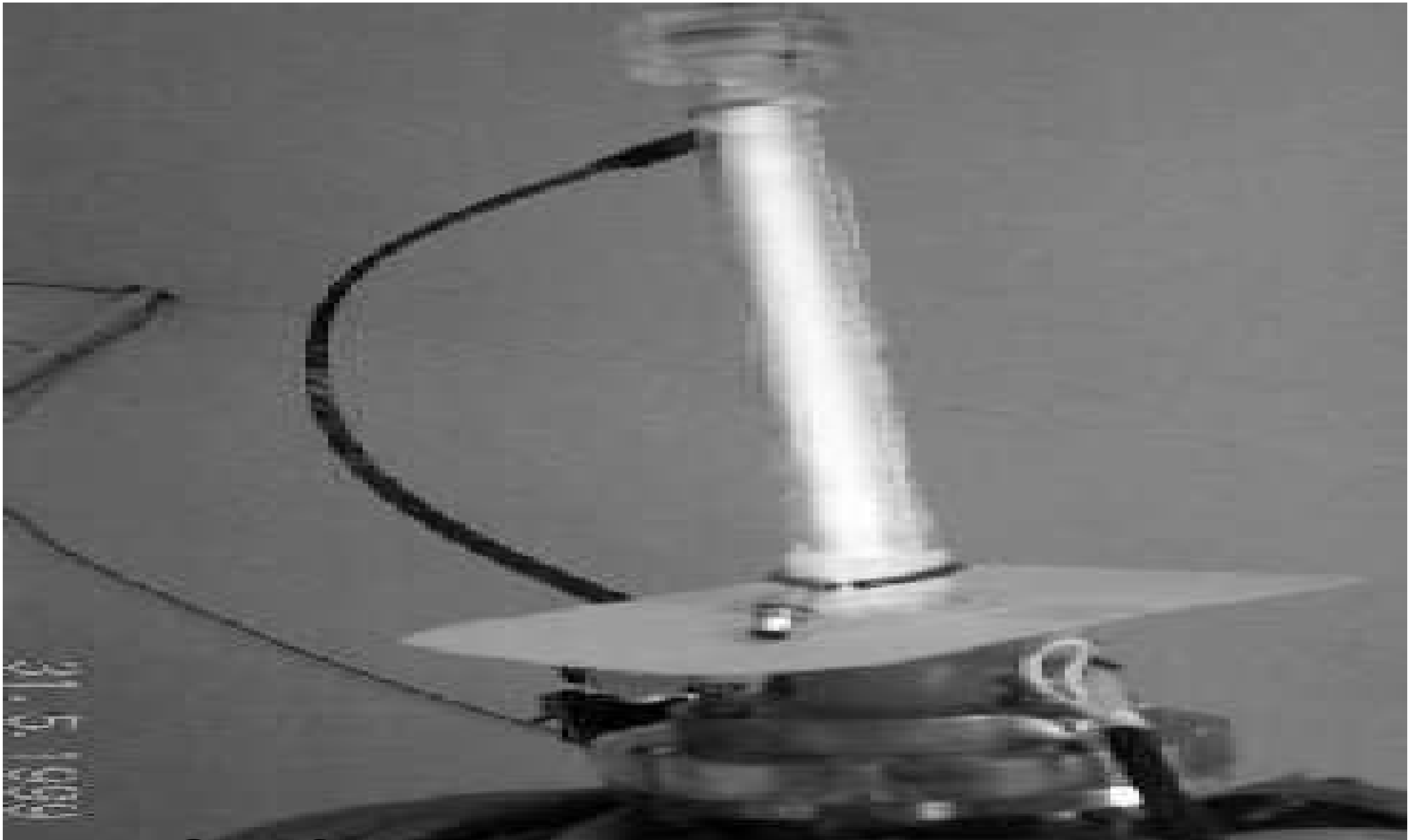
# INTRODUCTION

- **The fourth state of matter, now called plasma .**
- **Conductive assemblies of charged and neutral particles.**
- **Carry electrical currents and generate magnetic fields**.

- **In antenna’s the conducting element (metal) is replaced by plasma**
- **Plasma elements can be energized and de–energized in seconds.**
- **Hence prevents signal degradation.**
- **Types ex: dipole antenna, a loop antenna and reflector antennas.**



Surface wave driven plasma column

# OVERVIEW ON PLASMA ATENNA TECHNOLOGY

- **Antenna design has been an integral part of virtually every communication and radar application**

- **Antenna represents a conducting metal surface that is sized to emit radiation at one or more selected frequencies**

- **Employs ionized gas enclosed in a tube**

- **Employs solid metal wires as the conducting element**

- **"ringing" and associated effects of solid wire antenna design are eliminated**
- **When gas is charged, it becomes conductive, allowing radio frequency (RF) signals to be transmitted or received**
- **performance is equal to a copper wire antenna in every respect.**
- **It can be used over a large frequency range up to 20GHz**
- **Can employ a wide variety of gases**


Ionized Gas
Plasma Antenna


Plasma
Reflector

# TYPES OF PLASMA ANTENNAS

- 1: Helical plasma antenna
- 2:Spiral plasma antenna
- 3: Planer array plasma antenna

# MARKET APPLICATIONS OF PLASMA TECHNOLOGY

- **Antenna and Transmission Line Applications**
  - **Plasma Mirrors (Reflectors) and Lenses**

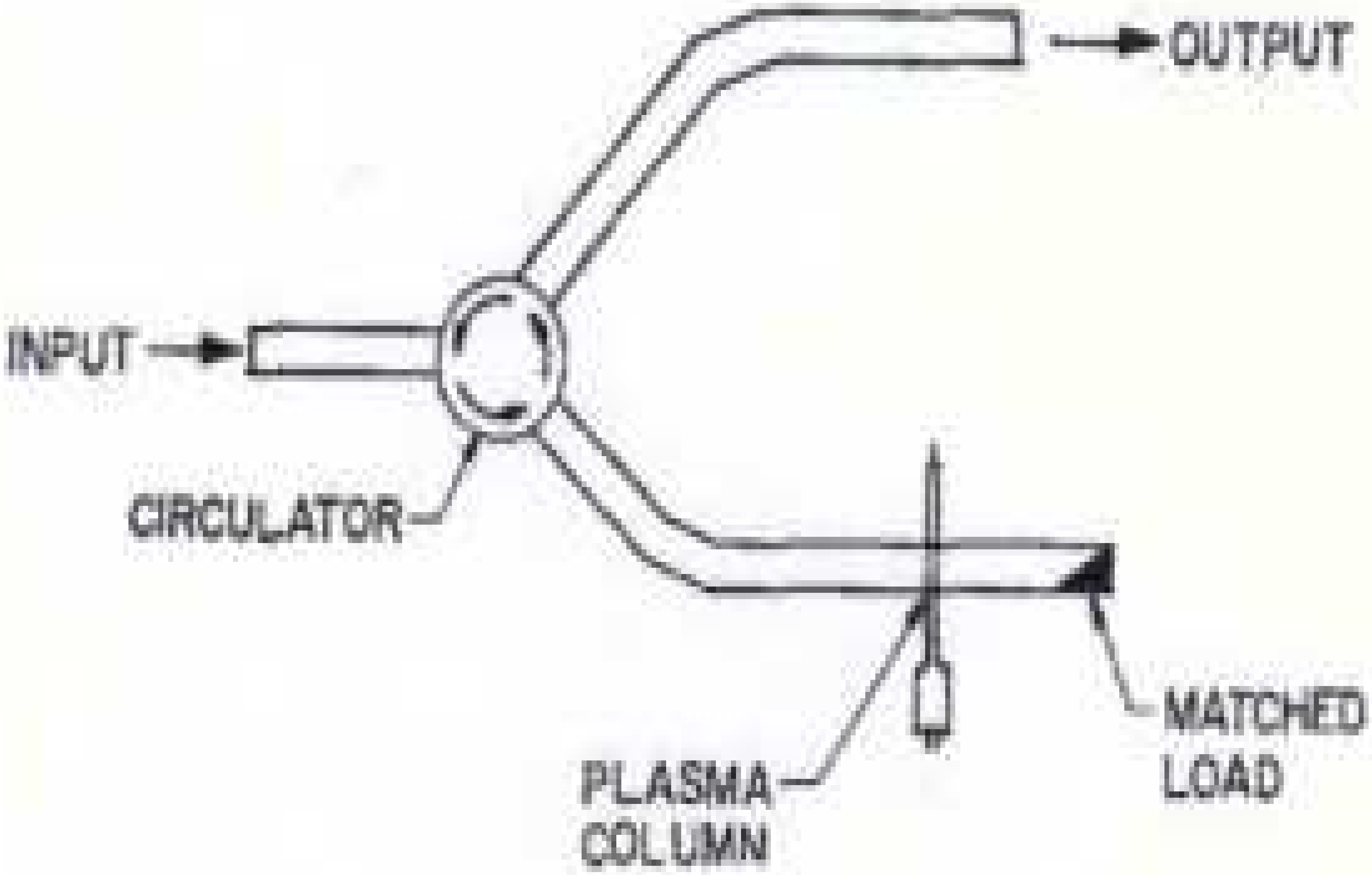
- **Potential military applications include:**
  - **Shipboard/submarine antenna replacements.**
  - **Unmanned air vehicle sensor antennas.**
  - **IFF ("identification friend or foe") land-based vehicle antennas.**
  - **Stealth aircraft antenna replacements.**

- Broad band jamming equipment including for spread-spectrum emitters.
- ECM (electronic counter-measure) antennas.
- Phased array element replacements.
- EMI/ECI mitigation
- Detection and tracking of ballistic missiles
- Side and back lobe reduction

- **commercial applications in telemetry, broad-band communications, ground penetrating radar, navigation, weather radar, wind shear detection and collision avoidance, high-speed data (for example Internet) communication spread spectrum communication, and cellular radiation protection.**

- **Microwave Devices:**
  - **Filters and Phase Shifters**
  - **Microwave Tubes**

# microwave band pass filter



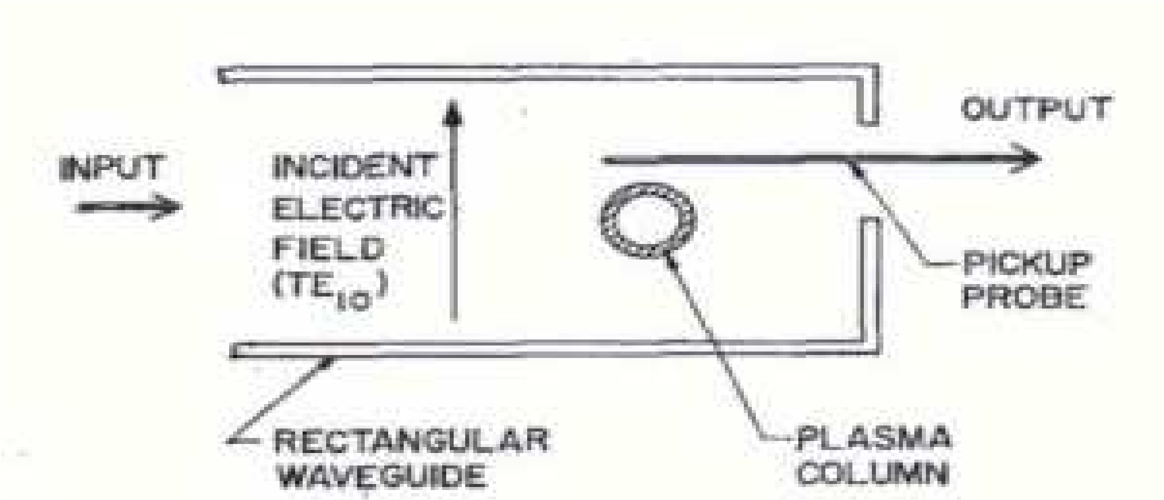
- **The input signal is dissipated in the load, or reflective, allowing the input signal to return to the circulator and exit the device.**

- **By changing the plasma parameters the pass band of the filter can be modified**.

- **multiple plasma columns could be inserted**

- **Variable time delay can be obtained by switching in different numbers of segments between the plasma columns**

# Phase Shifters




- **Plasma operating near resonance generates radial components parallel to the probe.**

- **Away from resonance there are no field components parallel to the pickup probe.**

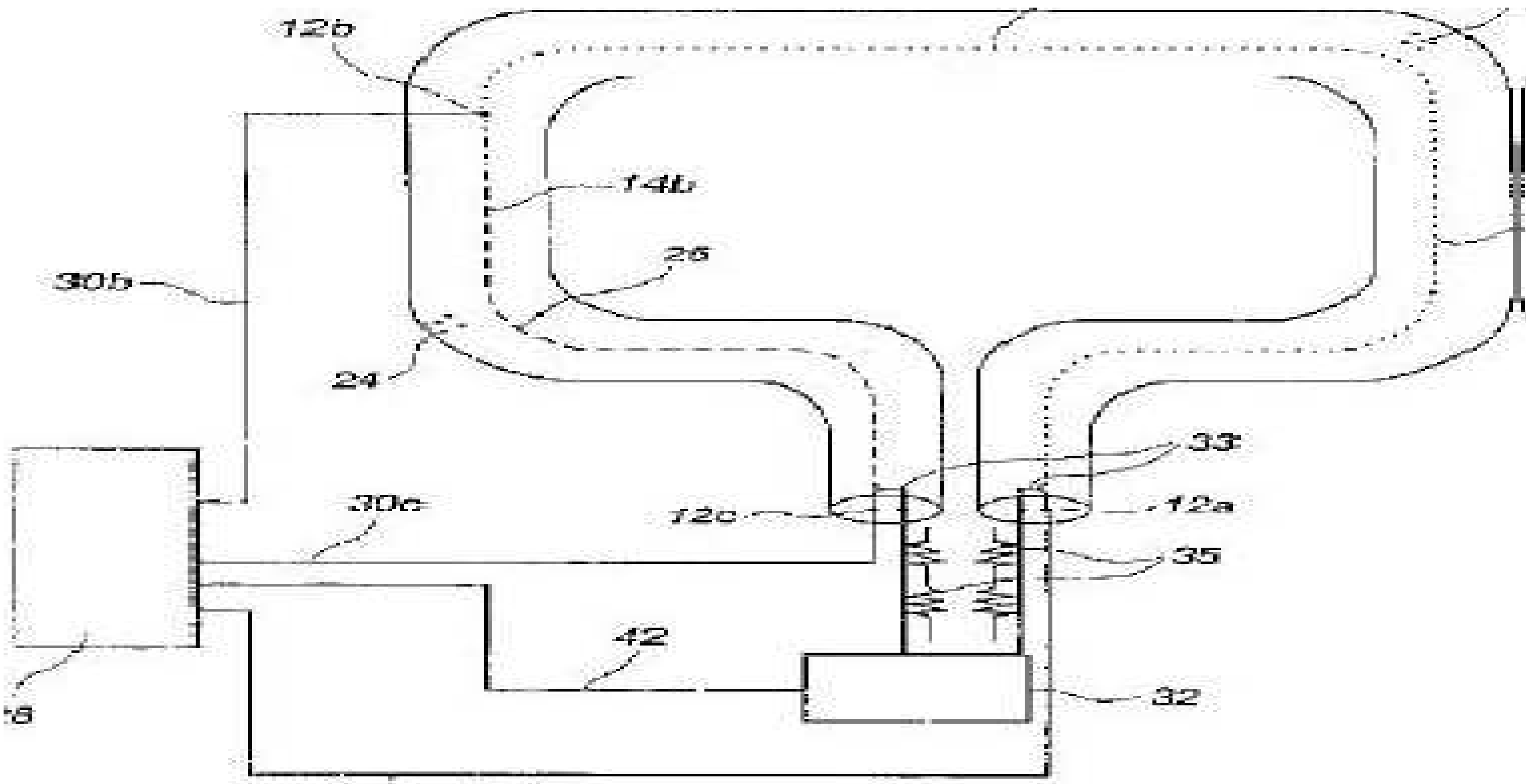
- **Variants of these two circuits can also serve as phase shifters**

- **Plasma switches have been used extensively for duplexing in radar,( i.e., to switch out high power transmitters during receive )**

# Microwave Tubes

- The presence of a controlled amount of plasma in traveling-wave tubes and backward-wave oscillators can lead to improvement in their operating characteristics above those of evacuated devices. Specifically, the bandwidth and power handling capability can be increased

# Loop antenna



# UNIQUE CHARACTERISTICS OF PLASMA ANTENNA

- **The gas ionizing process can manipulate resistance**

- **After sending a pulse the plasma antenna can be de-ionized, eliminating the ringing associated with traditional metal elements**.

- **When de-ionized, the gas has infinite resistance and does not interact with RF radiation.**

- **When de-ionized the gas antenna will not backscatter radar waves (providing stealth) and will not absorb high-power microwave radiation (reducing the effect of electronic warfare countermeasures).**

- **It provides increased accuracy and reduces computer signal processing requirements.**

- **These advantages are important in cutting edge applications for impulse radar and high-speed digital communications.**

# Based on the results of development to date, plasma antenna technology has the following additional attributes

- **No antenna ringing provides an improved signal to noise ratio and reduces multipath signal distortion.**

- **Reduced radar cross section provides stealth due to the non-metallic elements.**

- **Changes in the ion density can result in instantaneous changes in bandwidth over wide dynamic changes**.

- **After the gas is ionized, the plasma antenna has virtually no noise floor**

- **A circular scan can be performed electronically with no moving parts at a higher speed than traditional mechanical antenna structures.**

- **It has been mathematically illustrated that by selecting the gases and changing ion density that the electrical aperture (or apparent footprint) of a plasma antenna can be made to perform on par with a metal counterpart having a larger physical size.**

- low ionization level can be decoupled from an adjacent high-frequency transmitter

- Can transmit and receive from the same aperture provided the frequencies are widely separated.

- Plasma resonance, impedance and electron charge density are all dynamically reconfigurable.

- A single dynamic antenna structure can use time multiplexing

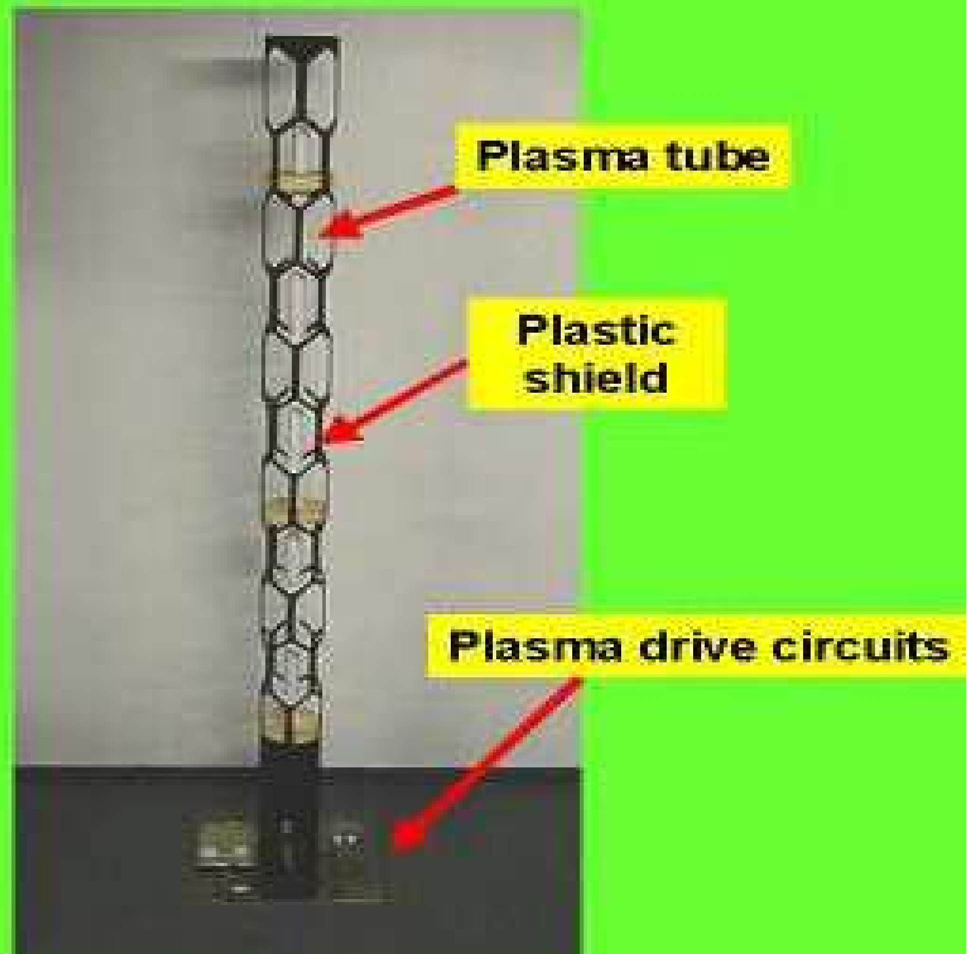
- Hence many RF subsystems can share one antenna resource reducing the number and size of antenna structures

# Linear plasma antenna

**Efficiency (~50%)**

**Low noise**

Australian Defense Science and Technology Organisation concept demonstrator



# SPONSORED WORK

- plasma antenna technology has been studied and characterized by ASI Technology Corporation

- The work was carried out in part through two ONR sponsored contracts

- NCCOSC RDTE Division, San Diego, awarded contract N66001-97-M-1153 1 May 1997.

- The major objective of the program was to determine the noise levels associated with the use of gas plasma as a conductor for a transmitting and receiving antenna.

- **The second contract N00014-98- C-0045 was a 6-month SBIR awarded by ONR on November 15, 1997**

- **The major objective of this effort was to characterize the GP antenna for conductivity, ionization breakdowns, upper frequency limits, excitation and relaxation times, ignition mechanisms, temperatures and thermionic noise emissions and compare these results to a reference folded copper wire monopole.**

- **ASI Technology Corporation is under contract with General Dynamics Electric Boat Division and in conjunction with the Plasma Physics Laboratory at the University of Tennessee, an inflatable plasma antenna is being developed.**

- **This antenna is designed to operate at 2.4 GHz and would be mounted on the mast of an attack submarine.**

- **In addition a prototype plasma waveguide and plasma reflector has been designed and demonstrated to General Dynamics.**

# TECHNOLOGICAL CONCEPTS OF PLASMA ANTENNAS

- **Higher Power**
- **Enhanced Bandwidth**
- **EMI/ECI**
- **Higher Efficiency and Gain**
- **Reconfiguration and Multi functionality**
- **Lower Noise**
- **Perfect Reflector**

# ADVANTAGES

- Reduced RCS
- Reduced interference and ringing
- Change shape to control patternand bandwidth
- Change plasma parameters
- Glow discharge increases
- visible signature *
- Good RF coupling for electrically small antennas
- Frequency selectivity
- Stable and repeatable
- Efficient
- Flexibility in length and direction of path

# DISADVANTAGES

- Ionization and decay times limit Scanning
- Plasma volumes must be stable and repeatable
- Ionizer adds weight and volume
- Ionizer increases power Consumption
- Not durable or flexible
- Higher ionization energy than for a tube

# CONCLUSION

- **As part of a “blue skies” research program, DSTO has teamed up with the ANU’s Plasma Research Laboratory to investigate the possibility of using plasmas like those generated in fluorescent ceiling lights, for antennas**
- **The fact that metal structures cannot be easily moved when not in use limits in some aspects of antenna array design.**
- **It can also pose problems when there is a requirement to locate many antennas in a confined area**
- **Weapons System Division has been studying the concept of using plasma columns for antennas, and has begun working in collaboration with ANU.**
- **The type of plasma antenna under investigation is constructed using a hollow glass column which is filled with an inert gas**
- **The metal whips that may be considered for a plasma replacement are anywhere from a few centimeters to several meters long.**

- **DSTO and ANU are now investigating the commercialization of the technology**.
- **Plasma antenna technology offers the possibility of building completely novel antenna arrays, as well as radiation pattern control and lobe steering mechanisms that have not been possible before.**
- **The research may one day have far reaching applications from robust military antennas through to greatly improve external television aerials**
- **To date, the research has produced many novel antennas using standard fluorescent tubes and these have been characterized and compare favorably with their metal equivalents..**
- For example, a 160 MHz communications link was demonstrated using plasma antennas for both base and mobile stations.
- Current research is working towards a robust plasma antenna for field demonstration to Defense Force personnel

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THANK YOU